Feilden's Magazine

THE WORLD'S RECORD OF

Industrial Progress.

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Industrial Progress.

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ANNOUNCEMENTS.

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In consequence of the large number of pages to be prepared and passed for press, the careful nature of the printing required for high-class production, the advance arrangements made for extensive circulation, and in order to facilitate departmental business, observance of the following rules is necessary:—

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For Buyers' Guide. Index to Advertisers, and Directory of leading British Manufacturers, see page ii. of second cover, and pages iii. to xiii. (in first part of Magazine).

All communications to be addressed

FEILDEN MAGAZINE CO.,
Temple Chambers, Embankment, London, E.C.

LIST OF CONTRIBUTORS.

The next and succeeding issues of FEILDEN'S MAGAZINE will contain articles specially contributed by, among others, the following distinguished writers, on subjects which they have made their own:—

Prof. Sir W. C. ROBERTS-AUSTIN, C.B., D.C.L., F.R.S.
Prof. ROBT. H. SMITH, M.I.M.E.
Prof. JOHN GOODMAN, M.I.C.E.
Prof. A. C. ELLIOTT, D.SC., M.I.C.E.
Sir EDWARD J. REED, K.C.B., F.R.S.
Sir WILLIAM WHITE, K.C.B., LL.D., F.R.S.
Dr. FRANCIS ELGAR
Prof. W. H. WATKINSON, M.I.M.E.
Prof. W. E. AYRTON, F.R.S.
C. F. CROSS, F.C.S.
T. SCOTT KING, M.I.M.E.
W. N. TWELVETREES, M.I.M.E.
W. FLETCHER, M.I.M.E.
Sir EDMUND VERNEY
HIRAM S. MAXIM
C. E. SPAGNOLETTI, M.I.C.E.
J. I. THORNYCROFT, F.R.S.
Dr. J. C. THRESH
C. ROUS-MARTEN
EWART C. AMOS, M.I.M.E.
Prof. VIVIAN B. LEWES, F.I.C., F.C.S.
A. R. BENNETT, M.I.E.E.
&c., &c., &c.

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The Governing Director of FEILDEN'S MAGAZINE takes this opportunity of publicly tendering his heartiest thanks to all those who have ungrudgingly and cheerfully accorded him their co-operation and services, which have tended so materially to the successful launching of an enterprise which, he sincerely trusts, will make for the increased industrial welfare of our country. All friends and well-wishers of the Magazine can contribute to that desired end by making it more widely and generally known.

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No Apology

is needed for the introduction of this Magazine. It is required by the new condition of things—called for by the national trade exigencies. Great Britain is facing keener competition in her engineering industries and commercial relations than ever before, a competition that is daily becoming more assertive, which threatens, if not tackled with the pertinacity, fixity of purpose and thoroughness for which our countrymen have become world-famous, to sap the very vitals of our national prosperity.

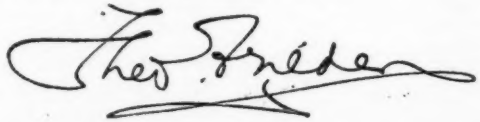
That the efficiency of its trade and technical publications is largely correlative with a nation's commercial success has never been better demonstrated than in the case of the United States, where indisputably high-class industrial literature has been the accompaniment of, and an overwhelming factor in, the phenomenal development of that country's business.

It is an astounding, not to say humiliating fact, that England, the birthplace of the great Engineering industries, the home of industrial enterprise and development, and the nation which has set the seal of progress on all others, should not have hitherto possessed a high-class representative trade-technical Engineering Magazine, having had to rely in this respect upon the industrial literature of the United States, which has successfully invaded this country, and has done so much towards popularising and fostering American specialities, to the displacement of a considerable amount of British trade.

I have set out with FEILDEN'S MAGAZINE to remove this reproach, and whilst its aim will be to furnish a record of the world's industrial progress, its primary object is to present everything that is best in British Engineering practice and productions. It will be absolutely *militantly* British in tone, character, and purpose, giving voice to the most effective means of retaining and expanding our trade and upholding the supremacy of British institutions and British prestige the world over. Further, its most strenuous efforts will be directed towards cementing the ties of Empire and Union and the consolidation of trading interests between the Colonies and the Mother Country.

I am producing this Magazine in conjunction with experienced and tried associates, under a combination of powerful influences, and it will endeavour, by the completeness of its organization and the authoritative nature of its special articles, compilations, and editorials, to command the closest scrutiny and broadest conviction among professional engineers, traders, and buyers of all countries.

To say that a publication with such a programme, securing in its literary columns the services of world-renowned experts, and utilizing all that is best in British typography, engraving and paper-making, merits the practical sympathy of everyone connected with the industries of which it will be the exponent *par excellence*, is not, I hope, exaggerating its pretensions. I ask, therefore, your earnest support on its behalf, feeling confident of your direct interest and concern in so exceptionally important a work.



"Lest we Forget!"

THE Englishman who has a spark of concern for the welfare of his country may be pardoned for a feeling akin to alarm at the somewhat weighty and significant words contained in the article contributed by Sir W. H. Preece in this, the initial issue of our Magazine. Are we, after all, falling back in the race of industrial progress? According to some of our greatest living experts, it would most assuredly seem so; but, surely, if it can be made manifest and brought home to our great manufacturing firms, our leading engineers, our merchant princes, our enterprising traders, and the thousands of solid, smart business men of the nation that we are being worsted, the danger can be averted and the impeachment wiped out! Can? It *must* be.

We of this journal have not set out to be alarmists; we decline to be funked, but we also refuse to shut our eyes to the militant danger with which our industrial supremacy is most unmistakeably threatened. Not all the talking in the world will get rid of facts. The hard, stern facts are simply that in more than one sphere of influence and in more than one branch of industry we are being beaten. In saying this, we are guilty of no breach of patriotism, it is because of our deep concern for our country's welfare that we make the statement. To say that we are behind generally in the race, as some would have us believe, is simply arrant nonsense; but there is not the smallest room for doubt that there is something radically wrong somewhere in connection with such incidents as the building of a bridge by Americans over a river that has been dyed with British blood in its acquirement; the placing of orders for locomotives and material in the United States by our great railway and dock companies; and the construction of our harbour defences with foreign workmanship. All the explaining away in the world *won't* obliterate the nasty fact that these things have happened, which should not.

Let us see to it that the importance of such matters is not underrated. Some of our contemporaries and public men of the Little England school have made light of these things, and have given it out that their value has been exaggerated. For our part, we don't think that they have been made enough of, and we claim that they present an object lesson which should be read to some purpose.

We deliberately assert that the National conscience needs awakening. The day that sees England's manufacturers unconcernedly allowing the thin end of the foreign wedge to be driven into trade which should rightly belong to Britain will be the signal for the rapid and permanent decay of our industrial prestige. It is a proud thing to say that, despite the keen, fierce rivalry of foreign nations, in the engineering industries we are an easy first, and that British ships take more than half the carrying trade of the globe. This is something to be thankful for, but it is also something to watch, conserve and expand. We cannot do it on old-world methods. Our American cousins have taken time by the fore-lock, and utilised the inventive genius for which they are so conspicuous and the natural resources of their country, to some purpose. Gradually, insidiously at first, aggressively to-day, they have been adopting every means of cheapening cost of production, making the most intelligent use of their working men, instead of treating them as mere machines—evolving plans and schemes for smart labour-saving devices, utilising the brains of the best technical labour drawn from the old country, discarding worn-out methods, making tools and machinery of a nature to suit special purposes instead of relying on the orthodox form, setting aside a proportion of their capital for experimental purposes, giving close study of the best and most economical forms of energy and power as applicable to their particular businesses, specialising in many industries, adopting the best

and most effective means of advertising their productions, and generally keeping in the march of progress, nay, more, getting in advance.

As the Americans have done this, so have the Germans built up a magnificent system of technical education throughout the length and breadth of the Fatherland, and equipped their sons with knowledge which, generally speaking for trading purposes, particularly in foreign countries, has fitted them to successfully cope with the most accomplished British commercial man in existence. France, Belgium, Switzerland, and other nations, only a comparatively few years ago looked upon as practically non-commercial, have to-day secured almost a monopoly of business in certain industries. Why have we allowed French engineers to steal a march on us, and, with America, to practically dominate the motor-car manufacture? Why are Swiss dynamos of certain types the *only* types which many of our firms in England will accept, and why have our locomotive engineers so neglected their own requirements and their manifest duty as to be unable to get *all* their locomotives built here—the land which gave *birth* to the locomotive? These are points that must be met, and met quickly.

What we want our manufacturers to realize to the full is that *the conditions under which Britain became famous in years gone by are not the conditions which prevail at the opening of the twentieth century*. A cursory glance at the atlas of to-day will eloquently demonstrate that though we possess the biggest slice of the earth's surface, we are hemmed in all round by new colonising nations, who are not only taking up fresh spheres, but aggressively and successfully attacking us in our own colonies, and bagging the trade of districts which have been all along looked upon as conservatively British.

The causes we have assigned, coupled with the insular prejudice and self-complacent strength of John Bull, have wrought the change, and the situation calls for the most active and comprehensive efforts on the part of Great Britain to forestall these inroads into her trade and to fortify her own position at the head of the world's commerce and industry. We can no longer afford to neglect those methods which our formidable rivals are adopting. We feel and know that our machines and our work stand for solidarity and worth, we also know that British engineers are the first the world over, and that a British trade mark is the synonym for genuineness and value, but that will not avail us against the insidious manœuvres of our commercial antagonists, many of whom are apparently willing to make a present sacrifice for a future profit. We must adapt our methods to modern advancement, shape our tools to obviously necessary requirements combining British solidity and strength with everything that is best and most delicate in foreign mechanical construction, teach our boys more than the three R's, work in closer union with the men (who must combine with the masters to maintain and defend the national supremacy), vigilantly study the tastes and needs of buyers in foreign markets, and make the best use of our brains to assimilate British bull-dog pertinacity and clean trading with the tactics and methods of the modern commercial nations of the world.

To say that we are busy now is but begging the question; so is everybody. There is a great wave of industrial activity overspreading the earth. Cecil Rhodes and other great empire builders have set the ball rolling, but in the cycles of trade, as with everything else, the hands of the clock are reversed at times, supply and demand fluctuates and a slack day comes. Those nations and those firms who look ahead now, who use every effort to preserve and extend their trade *no matter how full up with work they may be*, will come out on top; it is simply a case of the survival of the fittest.

Our goods may stand for solidarity and value, but don't let our conceit rob us of the magnificent heritage which has been bequeathed to us by the greatness of those distinguished Britishers whose names stand high on the scroll of fame, and who will go down to posterity as the pioneers of the world's Industrial Progress.

√Facts about our Ships and Shipbuilding.

THERE is little doubt in the average thoughtful and investigating British mind that the most pessimistic view of the general industrial situation of this country can embrace nothing which can reasonably suggest the remotest tendency towards a decline in our national resources in shipping, or in our capacity for shipbuilding. Some facts and figures, which are quoted in another part of this issue, present conclusive evidence in these particulars, and show that our old-time boast that "Britannia rules the waves" was never in the history of the nation more conclusively well founded than at the present moment. It seems that the entire tonnage of the world in ships amounts to a round total of 27,673,528 tons, of which enormous aggregate the United Kingdom and our Colonies own rather more than one-half, or to be precise, the immense and overshadowing proportion of 13,988,508. Deducting from this latter total 1,061,584 owned by the British Colonies throughout the world, the United Kingdom possesses no less than 12,926,924 tons. It is indeed a far cry from this predominating tonnage to the second biggest, which, it is hardly surprising to learn, is that of the United States of America, and which figures out to 2,465,387 tons. Germany takes third place with 2,453,334 tons, which thus follows closely upon American heels. All, probably, but those who follow maritime affairs closely, will learn with some surprise that Norway easily occupies the fourth place in the list with an ownership of 1,694,230 tons, exceeding even the wealth of France in this particular, which comes fifth with 1,242,091 tons. At this stage we omit our Colonies' maritime proportion, which, amounting to 1,061,584 tons, should come sixth; but if these figures be included in the grand total for the British Empire, the sixth place falls to Italy, which claims 875,851 tons. Then follow in the order given Russia, Spain, Sweden, Japan, and Denmark, with totals above 500,000 tons. The position occupied by Japan is worthy of note, as indicating the remarkable progress in shipping, as in other branches of industrial activity, for which the Oriental Britain is distinguishing itself since its emancipation from the crudeness and fanatic conservatism of its original Eastern civilisation. One other point is worthy of note, and that is the preponderance of steam tonnage as compared with that of sailing tonnage. The steam tonnage of this country amounts to 11,719,247 tons, and that of all the world besides is 9,000,000 tons. Germany and the United States take second and third place respectively.

The figures which relate to our shipbuilding are equally conclusive as to our national supremacy in maritime industry. Our new tonnage amounted to 1,303,894, represented by 690 vessels. The United States again secures second place with 169,196 tons for 140 vessels, and Germany third with 136,186 tons for 83 vessels. Next follow France, Italy, Norway, Japan, Holland and Belgium and Denmark in the order given. When we go a step further, and add to the total of our pre-existing tonnage our new tonnage, and still make allowance for the shipping built for, or sold to, other countries, and also the tonnage lost in the ordinary course of seafaring industry, we find to the credit of this country a gross tonnage of nearly 14,000,000 tons—a total the magnitude and potentiality of which it is almost impossible to realise. Truly, does it not afford a supreme element of satisfaction to our national spirit, a tribute to the sterling quality of our race-hood, a splendid justification to our Imperial aspirations? If one regards the facts and the figures to which we have referred in their commercial relationship to those which were recently voiced by Lord Brassey to an appreciative audience in the Antipodes, and which concerned more particularly our Navy and the importance of maintaining it in a state of unquestioned numerical and technical efficiency, one has before one a superb example of what race-unity and a belief in race-destiny, and all that is most inspiring in a genuine Imperial ideal, which may be militantly British

without being aggressively military, can accomplish, when tenacity of purpose is wedded to capital and enterprise, and to that progressive spirit which is the very breath of civilisation.

The Pacific Cable.

Of all the factors that are destined to play an integral part in the commercial and imperial welding together of that great confederation, the British Empire, none are likely to figure so conspicuously in contributing to that end as the permanent establishment of an Imperial means of effective telegraphic communication.

The tendency of all things is in the direction of disintegration, and the elements of disunion become stronger and more pronounced as we ascend the scale of the social community. Hence it is, that the difficulties experienced by the Home Government in fostering the common interests of, and in keeping in touch with the march of events in all parts of the extensive territories included under British dominion or protection, increase steadily under the uncertain and expensive system of news intercommunication provided by private capital and enterprise. In moments of crucial importance, and when great interests are at stake in connection with any portion of our more distant possessions—as, for instance, the recent trouble in the Transvaal—nothing is more common than to hear of a breakdown in one or more of the cables. Nothing is more significant, and nothing more conclusively demonstrates the urgent need of a system of Imperial telegraphic communication, whereby authentic and genuine news, by an official organization, would be guaranteed, instead of information of more or less value acquired in a haphazard and uncertain manner, emanating from unscrupulous persons.

To adduce only these extreme instances in support of the claim for an Imperial cable system would be sufficient, to say nothing of the more extended use of this wonderful means of intercommunication to meet the vital necessities of the mercantile world.

The chief fact which militates against the general adoption of the cable by the commercial communities is what has been aptly described as the cable tax—that is to say, we are completely in the hands of the commercial news companies, who, being practically free from competition, make their tariff rates sufficiently high to bring in an enormous profit to their shareholders.

Cheaper communication means increased business facilities; and although we are not at all in favour of merchants sending their cablegrams at the expense of the British taxpayer, we were nevertheless glad that Mr. Chamberlain and Sir M. Hicks-Beach, in receiving the deputation from the various cable companies dealing with Australasia and the East, protesting against the proposals made by the Government to contribute to the cost of an Imperial Pacific Cable, very properly raised the question of rates. As a just ground of complaint, the members of the Government instanced that the Companies, not content with a 7 per cent. dividend, had until recently absolutely concealed their profits, and created and set aside an enormous reserve fund, which might have gone towards the reduction of the rates and the construction of new and alternate lines of route.

We can only hope that the Government, having once set their hand to the plough, will see the matter through, and in as liberal a manner as that offered by India, Australia and the colonies in the Far East. Sentiment may be an important factor in the scheme, but there can be no question of loss in working even at greatly reduced rates, as the increased number of messages would prove more than ample compensation, to say nothing of the augmented business that the British trader would reap through this means.

To-day, more than ever, Imperial interests are predominant, and our future as a nation rests largely upon the wisdom or unwisdom of the measures which the Government adopt as a means of upholding and bringing into closer connection the various sections of the Empire.

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilization's timepiece put back 200 years."—RT. HON. LORD CHARLES BERESFORD, C.B.

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Golden Opinions! . . .

AT the moment of going to press we are proud and happy to be able to chronicle the most wide-spread approval of the *entrée* of this Magazine into the ranks of contemporary engineering journalism. We can say with confidence that never before in the history of the trade press has such a storm of congratulatory and eulogistic comment been showered upon a new industrial publication. The conception and programme of FEILDEN'S MAGAZINE appear to have met with the universal approbation not only of the daily press throughout the United Kingdom, but of a very large and representative number of leading scientists, engineers, and many others engaged in every branch of industrial activity. Elsewhere in this issue will be found a few opinions selected at random from the hundreds which have arrived at our offices. We say, with the strongest possible conviction, that there is not the smallest room for doubt but that this Magazine has come to stay, and it is something to be grateful for that even in "effete" England such a publication as this *was* wanted. We present the first issue with the confidence that we have produced a Magazine fully up to expectations. It will not be our fault if it is not worthy in every respect of British traditions.

From the Mersey to Australia . . .

ONCE more history is repeating itself. Again there is to be direct communication between the Mersey and the Antipodes, and again the fleet that will compass the distance will fly the flag of the White Star Line. It is more than half a century since such smart and luxurious clippers as the *White Star* and the *Red Jacket* carried half-a-million gold seekers to the Australian El Dorado, and more than thirty years since the first of the lineal successors of these—iron ships of ever-increasing capacity—the *Explorer*, left Liverpool for Melbourne. Since then the youthful colonies have grown to vigorous maturity, and the White Star Line has just commenced a new monthly service with a fleet of five magnificent steamers, the two first of which to be launched were the *Afric*, of 12,000 tons, and the *Medic*, of corresponding dimensions. These liners have a complete mechanical equipment suitable for the purposes of the trade in which they will be engaged, and especial provision will be made with extensive refrigerating plant to cope with large cargoes of frozen meat, fruit, dairy produce, and other perishable commodities. Another noteworthy feature will be absence of accommodation for saloon and cabin passengers. On the other hand there will be exceptional arrangements for third-class passengers. Altogether the departure is an interesting one, all the more so because, in some respects, it is a bold experiment. It is one thing more: it adds to the Pacific cable scheme, Imperial penny postage, and other departures which readily occur to one, another example of the broadening influence which our new imperial spirit—the Imperialism of commerce and kinship, not of militarism—is exerting upon every aspect of our national life, and which,

curiously enough, calls for first aid in the realisation of its aspirations upon the twin sciences of engineering and shipbuilding.

Iron in Kent . . .

THE announcement that a valuable discovery of iron ore has been made in Kent will excite little surprise in scientific circles, although it is none the less interesting on that account, and, to a large proportion of the thinking public, none the less welcome. It will in due time be succeeded by the inevitable cry of the prospective spoliation of beautiful Kent, which will be taken for what it is worth even by the most enthusiastic amongst the lovers of Nature. The precise degree of importance to be attached to the discovery, some particulars of which are given in another page of this issue, has yet to be determined, but so far as may be judged at present the find is likely to be taken seriously in mining and industrial circles. We can do very well with more available ironstone in this country, especially of the quality which is given out to be associated with this Kent ore. It appears that indications which presented themselves at a depth of 500 feet below the surface were more than realised at about 600 feet, when a 12-feet seam was pierced. The shaft is a 20-feet one, and from the limited area thus available in passing through the 12-feet seam 350 tons of ore have been recovered, giving on test proportions varying from 45 to 50 and 60 per cent. of iron, free from sulphur and phosphorus, and declared to be of a quality superior to the Wealden ironstone raised in Sussex a century and more ago. As indications suggest that there is a large area involved in this deposit, the chances are that the basis of a payable mining industry, of greater promise than the Kent coal scheme has as yet exhibited, is available, and it remains to be seen what enterprise and capital will do between them for Kent iron ore. The existence of a rich body of ore cannot be overlooked, nor is its exploitation under sound industrial conditions incompatible with a due regard for the conservation of the beauties and fertility of a most charming county.

The Americanising of our Railways . . .

IT seems only the other day that we were all startled by the announcement that the Midland Railway Company had decided to import Baldwin locomotives from America for service in connection with its express traffic. This was the most drastic departure from the conventional in British railway administration since the introduction of Pullman cars on this side. Now we find another of our most enterprising and far-seeing railway companies—the Great Eastern—going a step further in the Americanising of our railways by introducing a system of electro-pneumatic signalling and interlocking, which is of American invention, and has passed a most successful probation in that land of great railways. This system is described in some detail on another page. We are all for perfection in the engineering of our railroads, whether in permanent way, locomotives, rolling stock, or signalling accessories, and the conditions of travel and of our times demand that nothing that will promote speed, comfort and safety in transport should escape consideration. It is naturally, however, to be regretted that we are not self-contained in these matters, and that we have not only to take a few lessons from our foreign competitors—which is a comparatively small matter—but to draw upon them for material elements in railway equipment as well, which is no small affair. But, after all, while Baldwin locomotives are familiar to railway men in this country, though not to the average traveller, their importation to run on the Midland Railway under modern conditions, which have so severely tried—even, it is said, to the point of failure—the best engines the Company can turn out of their Derby shops, must be regarded as yet in the light of an experiment. So also must the installation of electro-pneumatic signalling at Bethnal Green Junction, although in America its success is undisputed. It is costly to instal, but economical in working; it minimises labour and diminishes risks at busy junctions and goods yards; it is simple, and is, in short, one of the refinements of American

railway engineering. Both departures must, however, to justify their adoption, be measured by the requirements of an exacting standard of efficiency which nothing we can submit on this side can shake.

Gold-Mining in India . . .

In the estimation of many who are in a position to give an authoritative opinion on the subject, we shall have to look to India for the next great gold-mining "boom." Some go so far as to say that the prospective production of gold in our Indian Empire will transcend all the previous records of modern times. Those who inquire carefully into the subject will see that there is a good show of justification even for such optimistic views; but if we content ourselves for the present with the actual results of legitimate mining enterprise in India, and leave speculation for the future, we have only to glance at the figures which indicate the progress of gold-production in the Mysore, to appreciate how substantially progressive and how abundantly promising it is. Further on in this issue will be found a short tabular summary of the gold output of the mines in Mysore, the principal gold-producing district in India. It will be seen that since 1894, when the gold yield aggregated 209,729 ounces, the total increased steadily each year, until last year—the record one in later Indian gold-mining—there was a yield of 415,147 ounces. For the first six months of this year the output has been 206,223 ounces, almost as much as for the whole of 1894. With such encouraging and progressive figures as a basis upon which to form a lay opinion, our British makers of mining machinery, for which India is a principal customer, may congratulate themselves on the prospect of increased demand from a quarter wherein foreign competition less keenly asserts itself than in some other mining countries.

The Utilisation of Blast Furnace Gases . . .

That the blast furnace is, or may be made, a good deal more than a blast furnace merely, is a point about which there is now little difference of opinion amongst advanced engineers. The suggestion that the waste effluent gases, the products of combustion in blast furnaces, might be utilised to advantage as a motive-power agency is no longer new, but its recognition as a basis for speculation and experiment opened up a wide field of which, perhaps, advantage has not yet been taken to the fullest extent. The interesting and discursive paper from the pen of Mr. Horace Allen, which appears elsewhere in this issue, on "The Iron Making Blast Furnace as an Ideal Power Producer," will probably serve to arouse more than passing interest in a theme the adequate appreciation of which is of the utmost importance to current engineering practice. The main points involved, too, are of vast importance to a wide range of power users, who might under many circumstances have recourse for power-supply purposes to a source of latent energy which they have hitherto failed to appraise at its proper valuation. It is more than likely that Mr. Allen's conclusions in some particulars will not escape, in certain quarters, an element of hostile review. When, for example, he boldly declares that with the adoption of the new and revolutionary system of blast furnace waste gas utilisation which he describes "no dangerous and wasteful steam boilers would be required," and when he directly points to "the cutting out entirely of boilers, with all their anxieties and dangers, water, fuel supply, etc.," he naturally invites a hornets' nest about his ears, and treads on the soft corns of convention and vested interest with a heavy foot. His paper, however, will serve a useful purpose in bringing before a large audience a fund of suggestive information, much of it fraught, under varying conditions, with great possibilities. He brings forward sound arguments in support of his premises; and although there are necessarily limitations alike to the adoption of the system advocated, and to the range of its application, there still remains a wide field for exploitation which is worthy of more than the merely passing attention of those in the engineering world who recognise the importance of utilising

every possible waste product to the utmost economical advantage.

The "Royal" Show at Maidstone . . .

One of the events of the year in engineering as well as agricultural circles, is the great annual show of the Royal Agricultural Society of England, which, as everybody knows by this time, was held this year at Maidstone. The show, in the implement and machinery yard—for we confine our attention thereto, and leave the prize heifer and the adipose pig to other pens—was an all-round good one. Of startling, epoch-marking novelties there were none. A new engine here, a new motor there, an improvement in detail in this, a praiseworthy simplification in that—such is about all that can be said on this score; and to such of the more important exhibits as these remarks apply, some detailed and illustrated reference is made elsewhere in our pages. Indeed, mere novelty is becoming a yearly decreasing quantity at these shows, and this may probably be regarded as a sign of the times, denoting some approach to finality, or, at all events, to some definite constructional standards which are far removed from mediocrity. It may also, in some smaller measure, be attributed to the comparative apathy with which the ruling powers of the Royal Agricultural Society of England seem to regard the claims of the implement yard, as compared with the live stock departments. It may be a moot point whether the aldermanic ox, groomed to a fault and panting for bare breath, or the perfect piece of machinery—rendered so, let us suggest, largely by the experiments induced by the offer of rewards for success—does more to promote the sum of human prosperity. We have our own opinion. Foreign competition in "show" live stock counts for little; in machinery and implements it signifies very much. The R.A.S.E. has in the past done much to aid our agricultural engineers to combat foreign rivalry. Might it not, consistently with its duty to live stock interests, do a little more now, and remove the reproach which, in the minds of so many, stands to its debit on this vexed question of awards?

Acetylene . . .

The rapidity with which Acetylene has established itself in favour as an illuminant of vast commercial and practical possibilities is one of the most interesting incidents in latter-day technical progress. Although discovered so far back as the thirties, acetylene seemed destined to remain a subject for laboratory study rather than for application to industrial purposes. Indeed it only came into commercial recognition less than five years ago, but during that short period it has been able to emphasise its adaptability to a wide range of utility, to establish its essential simplicity of production, and to impress favourably all impartial minds with its brilliancy and its beauty, enthusiasts even thus early pinning their faith to it as the "Light of the Future." One need not, however, go to any such extravagant length to avow a thorough appreciation of the new illuminant, which, after all, is only as yet in its infancy as a factor in trade and industry. In fact, the general public, and in a large measure the engineering public as well, know as yet little of acetylene. The series of articles on the subject which we commence in this number, and which come from the authoritative pen of Professor Vivian B. Lewes, who introduced the subject of commercial acetylene to an English audience from the lecture platform in 1895, will, therefore, be widely appreciated. The manufacture of calcium carbide, the compound which constitutes the raw material from which acetylene gas, by a very simple and almost elementary process, is produced, is already becoming an industry of rapidly increasing importance. The making of the gas generators and of the other paraphernalia incident to the production, storage and utilisation of the gas, represents a very substantial addition to our engineering trades; and in other directions which will readily suggest themselves, the future of acetylene presents a rich field for enterprise, invention, and the

remunerative employment of capital. In these and other respects the articles on the new illuminant, which will find places in our pages, will be something of a liberal education in the technics of what promises to develop into a very important branch of engineering activity.

Canadian Iron Interests . . .

From Kent to Canada is a far cry, but while in the homeland we want more iron, and are glad when we find it even in balmy Kent, in the colony they are in stress as how best to manage their iron interests, now that they have got them in plenty. The question of bounties on the production of iron is at present exercising the minds of Canadian legislators. Bounties on iron manufactured in Canada were introduced in 1883, and underwent several revisions as years rolled on, the last in 1897, since which time there have been bounties of $3 per ton on pig iron produced from Canadian ore, $2 on that produced from foreign ore, $3 on steel ingots having a basis of 50 per cent. of Canadian pig iron in their composition, and also $3 on puddled iron bars made from the Colonial pig. These bounties are to be reduced gradually by a sort of sliding scale arrangement until they cease altogether in 1907; that is to say, they may cease in that year—or they may not. This is just the point which is troubling our cousins at the moment. Bounties at the best are not theoretically the most desirable things, either in the interests of a State or of an industry; but once granted, and once they have so far served their purpose, it is a knotty point to hit upon the happy moment for their abolition. Meanwhile, since 1883 $1,107,530 have been paid in bounties in Canada on 615,153 tons of iron and steel, and the industry is in a most prosperous position. Its prospects are most encouraging, its possibilities infinite. In the direction of the development of a great iron and steel shipbuilding industry Canada has a splendid opportunity; and if, in the opening up of Canadian resources in this and other directions, more effort were made and inducements offered to secure the co-operation of British rather than of American capital, Canada and her magnificent resources in iron would benefit in corresponding measure. As a step in the right direction, it behoves Canadian legislators to be wary in their treatment of the vexed question of bounties in their iron trade.

Concerning Machine Tools . . .

If we remember rightly, it was the late Sir Joseph Whitworth—who certainly could speak with the full voice of authority on the subject—who declared that "The prosperity of England depends not only on the produce of her soil and mines, but also greatly on the number of self-acting machines she keeps at work. In proportion to the increase in the latter has been her increase in wealth and power." This is nothing more nor less than the truth, and if we narrow the matter down even to the limit of machine tools only, we shall still be well within an accurate appreciation of a great fact. The utilitarianism of the essential principle involved in the modern machine tool has been the parent of much of our progress, and many of our most potential developments, in latter-day engineering practice. But we have no monopoly of the machine tool in this country. America is a neck-to-neck competitor with us, and Germany, France, and Switzerland are also well in the field. The race for supremacy, however, is between our trans-Atlantic friends and ourselves. It is well that this should be clearly understood by our engineers, and it is just as well they should, in the matter of machine tools, appreciate where they fall short as well as where they excel. In this connection the series of papers by Mr. Ewart C. Amos, of which we publish the initial one in this number, will serve a useful purpose, in bringing forward the strength and the weakness of competing mechanisms of British and American production respectively. This is emphatically the age of the machine tool, and the tendency, which is more pronounced amongst American makers than our own, is to increase the application of automatic principles whereever expedient. This, Mr. Amos insists, is at the bottom of American success in

machine tool production, and it leads him to ask, "Why do we not encourage the automatic machine to the same extent?" "British manufacturers," he afterwards adds, "will lose nothing by looking into the causes that have made it possible for their present competitors to secure such a hold on the market as they have," and, while he fully admits that "our capacity for making high-class substantial tools is in no way changed . . . . considerable alteration will have to be made in certain directions if we are to retain our position as the leading tool-makers of the world." The articles which will follow the preliminary one will give the chapter and verse of their author's faith, in a manner which, by processes of comparison and deduction, is calculated to be of much service to students of the modern machine tool.

Whence comes it?
The British and American Workman . . .

JUST before these pages were closed for press, the projector and Managing Editor of FEILDEN'S MAGAZINE received an anonymous communication of a somewhat remarkable, though gratifying nature, which we think it is our duty to refer to and quote from, the writer not having expressed any wish that the sentiments contained in his letter should not be made public. Our unknown friend, who describes himself as a director of one of our largest engineering firms, excuses himself from disclosing his identity in the first instance, on the plea that his firm are likely to become advertisers in our publication, and he considers that publicity as to his identity might appear as though the opinions he expresses had been inspired. After some graceful remarks on the conception and *raison d'être* of our enterprise, which have given us intense satisfaction—inasmuch as it is such evident appreciation as this which makes men feel that labour, conscientiously undertaken, is not in vain—the writer gives us his experiences and opinions upon the respective merits of the British and American workman, which are worth repeating. He says: "I do not intend to cite any particular trade, but I most emphatically say that the American is a much more satisfactory individual to have under one's charge. It has been my lot to see Yanks and Britishers working shoulder to shoulder, under similar conditions in many parts of the world. In Egypt they stand together, amid that strange suffocating smell of dry hot sand; in the Straits, where a superabundance of drink is almost the only means of bringing a man sleep four nights out of the week, I have seen them with their sleeves rolled up elbow high; and in Japan, where competition between them runs very high, they are working themselves for all they are worth. Although the Britisher exerts every energy to his dying moment, I have had to confess that the Yank is the '*cuter*' man. He seems to live faster than his island brother, and taxes his abilities to a greater extent. Time is everything to him—more than money—it is life itself. Coupled with this all-absorbing desire to eliminate time is his British ancestor's thoroughness which is grafted into him, with the result that he accomplishes his work in a more perfect manner than the Englishman.

"It is consequently our duty as employers of labour to do all in our power to banish these slow and conservative notions from our workmen's mind. This indeed is no easy task, but it will have to be done. How? By educating the workman up to the employer's wants and the employer to the workman's mode of working. There should be much more consultation between the employer and the employed—not so much of the dogmatic authority on the part of the former, and less of the desire to do as little work as possible in a given time on the part of the latter. They must understand one another and work as two branches of the same class, and not two branches of two different classes. Then, and not till then, will the British workman give his employer the 20*s.* for a pound which is meted out by the Yankee." Our correspondent concludes by wishing our "new venture the success it so well deserves, trusting that in some degree it may be instrumental in bringing about the consummation of this much-desired requirement."

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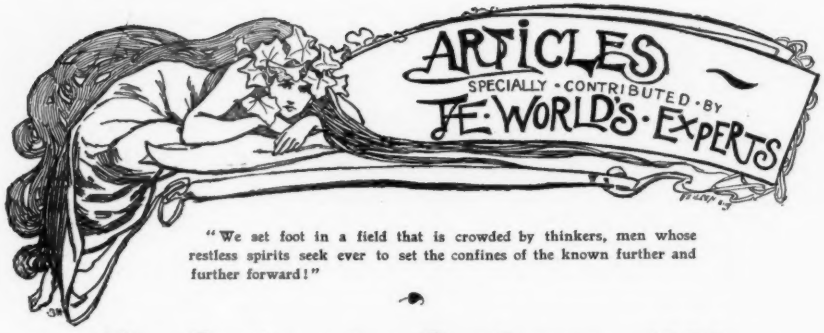
Photo by Elliott & Fry.

SIR W. H. PREECE, K.C.B., F.R.S.,

PRESIDENT OF THE INSTITUTE OF CIVIL ENGINEERS.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

The Engineering Conference, 1899.

By Sir W. H. PREECE, K.C.B., F.R.S.

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THERE is no name more familiar and more deservedly respected in the world of electric telegraphy to-day than that of Sir William Henry Preece, K.C.B., F.R.S. In all that pertains to practical telegraphy he is *facile princeps*, and his reputation is closely associated in the minds of the public with every material development which has taken place in connection with our postal telegraph system, of which he has for many years been the technical head and responsible administrator. Sir William is the eldest son of Mr. R. M. Preece, of Carnarvon, where he was born in 1834. Educated at King's College, London, he served a probation in the office of the late Mr. Edwin Clark, M.I.C.E., in 1852, entering the service of the Electric and International Telegraph Co. in the year following. Within three years he was promoted to the superintendentship of their southern district, and during the next few years received other responsible appointments, which he held concurrently. In 1870, when the Post Office assumed the control of the telegraphs, Mr. Preece was appointed a divisional engineer. Seven years later saw him holding the office of Chief Electrician, and in 1892 he was promoted to the higher office of Engineer-in-chief to the Post Office, the duties of both offices being carried out by him with the greatest acceptance until his retirement the other day according to the age limit rules of the Civil Service. Sir William's experience, however, will not yet be entirely lost to the country, as he continues to act as consulting engineer to the Post Office Department. A pioneer in telegraphy in every sense, Sir William Preece has distinguished himself alike as an investigator, inventor, engineer, and administrator. He has attained celebrity also as a lecturer and as a prolific author on subjects coming within his domain. A member of many learned societies, he is also a Fellow of the Royal Society, President of the Institution of Civil Engineers, a past President of the Institute of Electrical Engineers, and a permanent official of the British Association. Few official lives have been associated with departures more immediately calculated to promote civilization and the welfare of humanity than that of Sir William H. Preece, who has retired from active service in the full vigour of his faculties, full of honours bestowed upon him with lavish hand, and full of the respect of his fellows.

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IN 1897 the Institution of Civil Engineers essayed, for the first time, an Engineering Conference in London. The provincial members of all classes found so much difficulty in attending the ordinary weekly meetings, that a suggestion emanated from some of them that they might have a week in London, to see what was to be seen, to hear what was to be heard, and to meet their confrères in social intercourse. Moreover, many colonial members are always to be found temporarily at home on holiday or business, and anxious to learn all they can of home experience and up-to-date facts. The first Conference, under the presidency

of Sir John Wolfe-Barry, was such a success that the council decided to make the Conferences *biennial*, and, accordingly, the second was held on June 7, 8, and 9, with much *éclat* and satisfaction.

Conferences facilitate intercommunication among members of one community, and by bringing people into personal and social relations with one another, they promote harmony, allay jealousy, and encourage progress. Moreover, civil engineering is now so widely extended and so universal that electrical engineers, sanitary engineers and mining engineers scarcely realise the fact that they are only species of one genus. By associating the conference with the annual conversazione, in the best time of the year and during the London season, and by arranging well-considered excursions and visits to works in progress or to those complete, pleasure is combined with business, and entertainment with experience. Knowledge is best disseminated by exciting discussion, and the lessons of experience are often extracted by criticism or inaccuracy. Hence papers are prepared by those who have been selected for the purpose from their known experience and skill. The result was very successful.

The Conference was divided into seven Sections, the first dealing with

RAILWAYS,

presided over by Sir Douglas Fox, and several important questions, such as the formation of standard gauges for light and mountain railways, especially in the colonies, where great variety of practice exists. In Africa the Uganda Railway is built on the metre gauge, while the Buluwayo Railway, which will eventually meet it, is on another gauge, viz., 3 ft. 6 in. The consideration of some uniformity or system in gauges will probably be relegated to a committee by the council of the Institution. The Board of Trade has already sanctioned five different gauges on forty-two light railways. The utilisation of water power in working mountain railways and the danger of too narrow gauges were mooted, especially with reference to the great success of this mode of working in Switzerland.

An excellent paper by Mr. Alexander Ross on the advantages and disadvantages of uniting

LOCK AND BLOCK SIGNALLING APPLIANCES ON RAILWAYS

elicited much information on the safety of railway travelling, while Mr. Boult described his efforts to mitigate the present barbarous, dangerous and irregular system of fog-signalling by detonators by introducing mechanical appliances which gave visual signals to the drivers. The most expeditious method of re-laying railways without interfering with the safety, regularity and economy of traffic was introduced by Mr. Footner, and led to an excellent discussion.

Sir John Wolfe-Barry expressed a favourable opinion of the American practice of lubricating ballast with oil to allay dust and promote durability. Throughout these very practical discussions the great variety of practice in this country adopted by our engineers was prominently brought out. The form, length, and weight of sleepers and rails, the method, cost, and time of relaying, the handling and transport of materials, the dimensions of trucks and goods trains,

THE DIFFERENCE IN RAILWAY PRACTICE AND MANAGEMENT IN AMERICA AND ENGLAND,

the causes and cures of earth slips in the slopes and embankment of railway cuttings and embankments, indicated great divergence of views, and led one to hope that a result of such conferences as this would be to introduce into our country more uniformity and less individuality. Mr. Forman stated that every penny per ton saved in handling minerals meant one million pounds sterling. *English engineers run too much in one old groove*, while each man relies too much on his own experience and too little on that of others. Faith in others certainly leads to progress, and foreign travel opens the mind, enlarges one's experience, and breaks down insularity.

The second Section, presided over by Sir John Wolfe-Barry, dealt with the all-important

NATIONAL QUESTION OF HARBOURS, DOCKS, AND CANALS.

The first paper read, "On the Discharging and Loading of Large Steamers," by Mr. Hunter, of the Manchester Ship Canal, led to an interesting discussion.

The extraordinary increased dimensions of steamers during the past decade, due to severe home and foreign competition, and the necessity for their rapid discharge and change, have led to some novelties, especially in labour-saving appliances, on the Manchester Canal. Ships are there discharged, especially if laden with timber, on both sides at the same time, and warehouses of extraordinary height and dimensions have been erected. Attention has also for the same reason been forced to the length, width, depth, shape, and mode of construction of locks, entrances, and graving docks. The whole of the first day of Section II. was spent with great profit in discussing these questions raised by Mr. Hunter and Mr. Davison. The Manchester Ship Canal has an effective depth of 26 feet, but the Suez Canal is being dredged to 30 feet. There is a tendency to increase the depth of ships, and especially of warships, but Froude established the theory that increase of beam was the most economical way of giving greater carrying capacity. This is being forgotten. Ships pass through the Manchester Canal with only 6 ins. clearance, but they sometimes "smell" the ground. When they enter the fresh water portion they draw 5 ins. more. The limit of speed at Manchester is 6 knots, at Suez 5 knots.

Mr. Lyster described the

WONDERFUL AND SUCCESSFUL SAND PUMP DREDGERS

which have increased the depth of the channel, and maintain it open over the Mersey bar. Sand at depths between 20 and 30 feet is not disturbed by anything but the greatest storms, and if the surface action due to waves is counteracted by the tide the desired depth of the channel is permanently maintained.

Mr. Shield brought forward some "Notes on the Effects of Waves on Breakwaters in different depths of water," and Mr. Sandeman on the "Design of Breakwaters," which were discussed together. The waves at Peterhead reach a height of 30 feet, and the foundations of the breakwater were carried down to a depth of 46 feet. The stability of these structures depended entirely on their foundations. When they can be carried down to the solid as at Dover and Folkestone, the engineer is freed from care and anxiety.

Section III. dealt with Machinery, and very properly met in the new building of the Institution of Mechanical Engineers under the presidency of Sir Andrew Noble, who called attention to the value of automatic tools, and to the

SEVERE RESTRICTIONS PLACED ON LABOUR BY COUNTY COUNCILS

in their specifications, and by the action of Trades Unions. We were being beaten in competition by internal mismanagement and by union tyranny.

Mr. Webb gave an admirable summary of the work done on the North Western Railway in the evolution and use of the compound locomotive. The mean expenditure of coal per mile per engine came out at 38·1 lbs.—the saving due to com pounding being from 19 to 20 per cent. The smaller burning of coal meant less wear and tear. For every £1 spent on coal the London & North Western Railway earned £28 1*s.* 8*d.*

Mr. T. Parker read a paper "On the relative advantages of different kinds of power for tramways, light railways, and motor car traffic, both heavy and light." Naturally, as an electrician, he gave the palm to electricity for its flexibility and economy.

Mr. Brett brought forward the subject of "Forgings and the Machines used in producing them," and Mr. Arthur Greenwood of "Machine Tools with special reference to American and German Practice as compared with English." This paper excited an interesting discussion on the labour question, and it led to a very pronounced opinion in favour of the metrical system.

Mr. Pitt introduced the subject of "Cranes and the Power to be used with them." He preferred steam for single cranes, but

ELECTRICITY FOR OVERHEAD TRAVELLERS.

The defenders of hydraulic power fought their case well, and made the discussion lively and interesting. Sir Alfred Haslam gave an instructive paper on "Separate Condensing Plants for Factory purposes"—but there was no time to discuss it well.

Section IV. was devoted to Mining and Metallurgy, and it was presided over by Mr. Windsor Richards. Foreign competition was the text of his address, and full intercommunication of ideas and experience, so as to secure new processes, methods and labour-saving machinery, the weapons of defence. America was now our schoolmaster. We taught them originally; but they have bettered our teaching. A visit there is instructive.

Mr. Martin gave a paper on "Modern Improvements in Coal Mining: Winding from Deep Mines," which led to an extremely interesting discussion upon the use of wire-rope guides at great depths, and the economy of deep mining.

"Gold Mining" was introduced by Mr. Hayes Hammond and by Mr. Irvine, and these two papers elicited another valuable and instructive discussion.

Mr. E. Coppée brought forward the subject of "By-product Coke Ovens," which led again to the

INJURY DONE TO OUR COMMERCIAL SUPREMACY

by the much vexed labour question. In Belgium labour is one-third cheaper than in Wales, the workmen are more amenable to discipline, and they are more handy in their work.

Mr. Hadfield introduced "The Influence of Casting Temperature on Steel," while Mr. Childe and Mr. Garforth read two notes on "The Comparative Advantages of Electricity, Steam and Compressed Air for Mining Purposes." It was mentioned in one case that with compressed air 111 H.P. was needed to do work which electricity did with 17 H.P. The superior efficiency of electricity was unquestioned, but fears were expressed as to its safety.

Section V., dealing with Shipbuilding, was presided over by Sir Edward Reed. Mr. E. L. Martin commenced the proceedings with a broad and general paper on "Swift Passenger Steamers of moderate size," which led to a description by Mr. Barnaby of the new P. and O. 20-knot boats, carrying 50 passengers and mails between Brindisi and Port Said. The chief element of up-to-date improvement in speed was according to Professor Biles lightening the weight of hull in proportion to its size. This was not the case with the P. and O. boats. The chief feature of these boats was the introduction by the P. and O. Company of twin screws.

THE WATER-TUBE BOILER QUESTION

cropped up in the discussion to show once more the essential difference between the conditions of manœuvring warships and those of the mercantile marine.

Professor Biles presented a note on "The Practicability of so Constructing Merchant Steamers as to render them readily available for War Purposes," and Mr. De Rusett one on "Recent Developments in Cargo Steamers," in which the evolution of steamers of great size, rivalling the *Great Eastern*, was developed.

Mr. Maginnis read a paper on "Graving docks, blocks and appliances," which owing to legal proceedings connected with an accident to the s.s. *Fulda* in one of the graving docks in Liverpool, excited an admirable discussion, opened by Sir William White. Wood-blocks were preferred to cast-iron, and opinion was divided as to the relative merits of elm and oak.

Mr. R. T. Napier read a paper on "The Application of Mechanical Devices to the Rivetting and Caulking of Ships, also the Material of Ships' Rivets." Sir William White again led the discussion, which rested chiefly on the

RELATIVE ADVANTAGES OF HYDRAULIC AND PNEUMATIC RIVETTERS,

and upon the uses of electricity. Here again America was shown to be ahead of us.

Section VI. dealt with Waterworks, Sewerage, and Gas Works. It was presided over by Mr. G. H. Hill. The first paper read was on "The Use of Filtered Flood Water," by Mr. M. W. Harvey, the engineer to the West Middlesex Waterworks. Filters were not a perfect obstruction to bacteria. Bacteria apparently

floated in shoals. Their numbers were very irregular, varying from 6 to 100 colonies per cubic centimetre, even in the same water on the same day.

Mr. James Watson read a paper, "A Consideration of the Rate per Head per Day of Supply in different Towns, and of the Causes which Increase or Diminish it in particular Instances." The figures are very variable. They ran between 10 and 40 gallons. In Sheffield the supply per head per day, which had been 20½ gallons, rose to 41½ gallons on the introduction of the constant system. When fittings were set in order and proper inspection introduced the supply came down to the normal rate of 20 gallons. Trade, municipal and domestic supply varied very much in different places. It was mentioned that the American gallon was smaller than the British. It weighs 8⅓ lbs., while the British weighs 10 lbs. if of distilled water at maximum density. It is thus 17 per cent. smaller.

THE BACTERIAL TREATMENT OF SEWAGE SLUDGE

was raised by Dr. Sims Woodhead, who submitted a note on "Sewage Sludge Disposal by Natural Agencies." Nature was difficult to imitate, but the more closely this was done the better the results would be. Life lives on life, and harmless bacteria live on harmful ones. The wars of bacteria differ from those of the human race, for they lead to the saving and not to the destruction of human life. In this field engineers and biologists were working hand in hand.

Mr. Foulis read "Notes on the Recovery of Residual Products from Coal Gas during the Progress of Purification." Mr. George Livesey advocated that gas manufacturers should produce as much ammonia as possible, for the demand for it for manure was unlimited.

Mr. C. C. Carpenter read a very interesting and instructive paper on "Labour-saving Appliances in Gas-works," which initiated an equally interesting discussion.

Section VII. dealt with the applications of electricity, and was presided over by Professor Kennedy. The proceedings commenced with an exceedingly well-written provocative paper by Mr. Swinburne on "Methods of Electrical Transformation." The object of the paper was fully attained, for it led to an animated discussion.

Professor Ayrton then read a paper on "Some non-integrating Electric Meters," and Mr. G. C. Cunningham on "Mechanical Traction by Electricity," which gave some extremely valuable practical information. In Montreal the cost of producing electrical energy was about one farthing per kilowatt hour, the cost per car-mile less than one halfpenny. Montreal is a hilly place, and the cars absorb two units per car-mile. The consumption of coal was 3·48 lbs. per unit. The lowest cost of horse traction in the United Kingdom is that in Glasgow, which was 3½*d.* per car-mile. These are

POWERFUL FACTS IN FAVOUR OF ELECTRIC TRACTION.

Mr. Parshall supplied a paper "On the Economical Transmission and Distribution of Electricity from a Distance." He was unfortunately too unwell to be present, but he originated a very valuable discussion upon the relative merits of alternating and continuous currents at high voltages. At Telluride (U.S.A.), 40,000, and in Hamilton (Canada), 22,400 volts are in use. This is for triphase transmission; 2,500 volts appears the highest in use for continuous currents.

The proceedings in every one of the Sections were well sustained; and though the attendances were very satisfactory, they varied very much in quantity. Each Section was distinctly a success, and the excursions and visits were very enjoyable. Many of those to whom tickets had been allotted on their applications failed to turn up, but, which was worse, they neglected to return their tickets, and thus deprived their colleagues who were applicants, of all chance of joining the excursion. This act of thoughtlessness led to some disappointment, and was distinctly discourteous to those who invited the members to inspect their works.

If this Conference has done no other good, it has done this: it has made our engineers alive to the dangers of foreign

competition, and to the fact that *we can no longer pride ourselves on our commercial and industrial supremacy*. We are a foolish and conceited nation, and blind to our own deficiencies. Germany is far—generations—in advance of us in education, and America is equally in advance of us in labour-saving machinery, standardisation of patterns, workshop management, and manufacturing methods. The three elements of

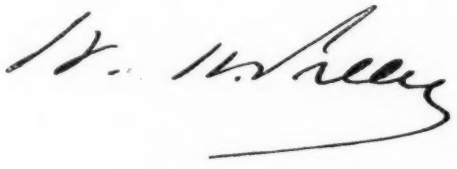
OUR RETARDATION IN THE RACE OF INDUSTRIAL PROGRESS

are our own ignorance, the political flirtation with the working man, and the tyranny of the Trade Unions. The cures are the education, combination, and association of the masters, the education of the politician, and the allocation of the Trades Unions to their proper sphere of providence and thrift, and the absolute prohibition of their interference in trade conduct and in workshop management. The working man must become, as he has in the United States, *a reading, thinking, technical expert, who takes a pride in his own work and a patriotic delight in the advance of his nation*.

Again, it is quite clear that

WE MUST REVISE OUR WEIGHTS AND MEASURES.

The metrical system is bound to be introduced. We cannot do without it. Even in tons and gallons the Americans have run away from us. Their ton is 2,000 lbs., ours, 2,240 lbs.; their gallon is 8·3 lbs. of water, ours, 10 lbs. Confusion has become more confounded. One redeeming feature is that, in electricity, we have one language and one system of measures, and all nations are in harmony. If ordinary common-sense does not settle the question, electricity will, for one pleasing feature in the past Conference has been this, that in every Section, electricity played some important part or other. Since, therefore, every branch of engineering is dependent more or less upon the aid of that form of energy whose measurements are based on the metrical system, it is difficult to see how the most determined conservatism can resist much longer the introduction of the system into engineering generally.



Recent Characteristics of British Locomotive Engineering.

By CHARLES ROUS-MARTEN.

MR. CHARLES ROUS-MARTEN, who is one of the best-known British writers on locomotive engineering, was born and educated in England, but has spent a considerable proportion of his life abroad, including two lengthened periods in New Zealand. In the year 1884 he returned to England with credentials from the New Zealand Government, and during that and the following year made an elaborate inspection of all the British railways and their working. The results were embodied in a report to the New Zealand Minister for Public Works, and being published under the title "Notes on the Railways of Great Britain," were very favourably reviewed in England and other countries. Subsequently, Mr. Rous-Marten made a similar examination of the railways of New Zealand, New South Wales, Victoria, South Australia, and Italy, and a less complete one of Ceylon and Swiss lines. Returning to England early in 1893, he commenced the minute re-examination of the British railways, which he has continued ever since, and some of the results of which have already been published in England, Belgium, and America. Last year Mr. Rous-Marten conducted an extensive series of experiments and investigation on the chief railways of France. He has contributed largely on the subject of Locomotive Engineering to the columns of "The Engineer," "The Engineering Magazine," "The Railroad Gazette," "The Railway Magazine," and other technical periodicals, and for some years past has written for the Bulletin of the International Railway Congress, published in Brussels, an annual review of the progress of British locomotive engineering during the year.

DURING the past five years there has been a remarkable wealth of new developments in locomotive engineering. It may, indeed, be said with justice that the last quinquennium has been more prolific in this respect than the previous quarter of a century.

It is true that the twenty-five years after 1870 witnessed the introduction of many fresh and notable locomotive types. The late Mr. Patrick Stirling's 8 ft. and 7 ft. 6 in. single-wheelers on the Great Northern, and Mr. F. W. Webb's coupled and three-cylinder compound engines on the London & North-Western, Mr. W. Stroudley's "Gladstones" on the London, Brighton & South Coast, Mr. W. Adams' "577" class on the London & South-Western, Mr. W. Dean's 7ft. 8 in. singles on the Great Western, Mr. T. W. Worsdell's compounds on the Great Eastern and North-Eastern, Mr. S. W. Johnson's single and coupled expresses on the Midland, Mr. C. Sacré's single and coupled on the Manchester, Sheffield & Lincolnshire—now Great Central—and Mr. D. Drummond's coupled type on the North British and Caledonian will at once occur to the memory. All were excellent engines—indeed, virtually are so still—and all have

done admirable work under my own observation.

But the number and variety of the new types which have appeared during the past five years are surprisingly large—disproportionately so, in fact—as compared with the previous experience of a period five times as long. Yet each novelty has appeared to bring with it its own justification of existence. There has been a continuous modification of the conditions which have to be fulfilled by a successful engine and there is a steadily growing tendency to

THE SPECIALISATION OF LOCOMOTIVE DUTY.

This has involved the perpetuation of a greater variety of types than was expected a few years ago to be necessary as a permanent condition of locomotive practice. These observations apply mainly to what is perhaps the most important, or at least the most prominent phase of railway work—the fast and heavy through traffic for long distances. It is this which has chiefly taxed the ingenuity and inventiveness of locomotive engineers.

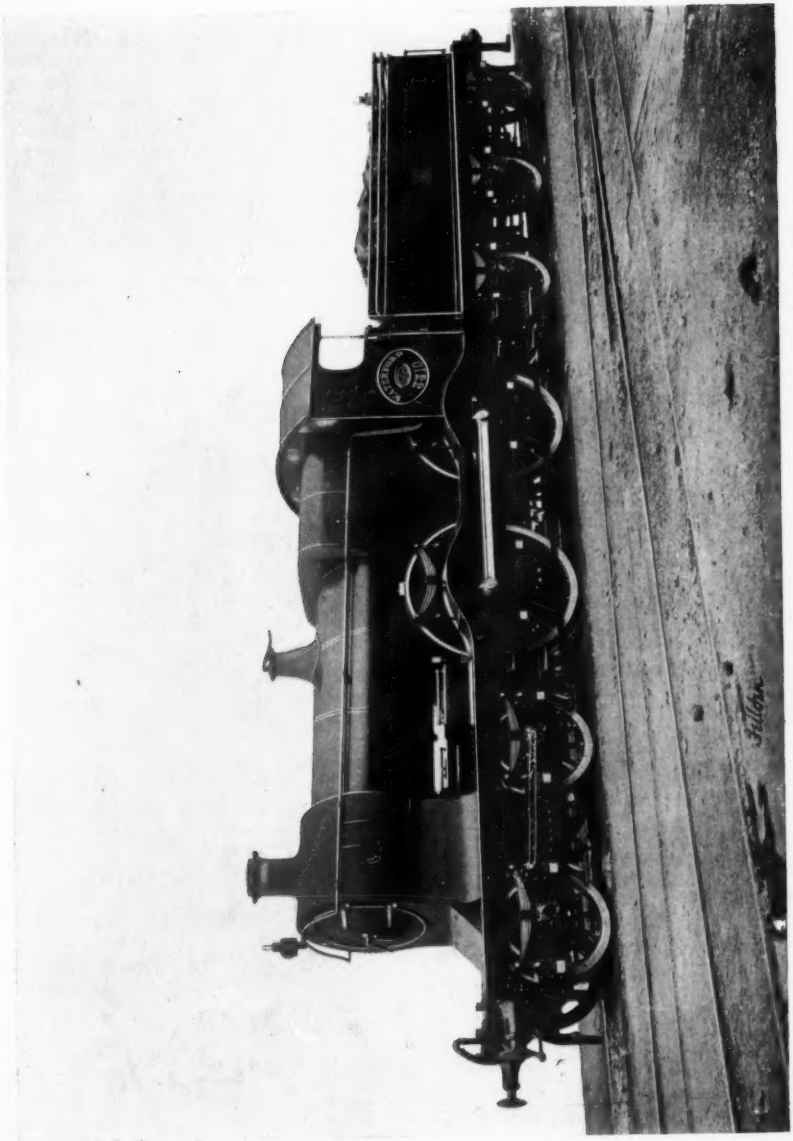
In the same period, the two other main divisions of railway work, suburban and goods traffic, have produced relatively few novelties in design. Each of these important classes of traffic is subject to special limitations which do not apply to the "through" work, and consequently the locomotive types introduced many years ago for the performance of those respective duties still remain adequate. In details and dimensions they have undergone modification. In general principles and design they remain virtually what they were in the comparatively early days of railways. That is to say, suburban traffic is, with few exceptions, worked by four-wheel-coupled engines, having either the two front pairs of wheels coupled and a trailing four-wheel bogie, or else the two middle pairs coupled and radial axles to the leading and trailing pairs. The coupled wheels are usually 5 ft. to 5 ft. 6 in. in diameter, the cylinders 17 to 18 in. diameter, 24 to 26 in. piston-stroke. The Brighton goods engine is still the "DX" of the late Mr. John Ramsbottom, having six-coupled wheels and inside cylinders. The wheels are usually 5 ft. in diameter and the cylinders 17 to 18 in., with a 24 to 26 in. piston-stroke. These respective designs and dimensions have proved ample for the service required, and limitations of platform and siding accommodation at present preclude any material increase in the loads required to be dealt with alike in suburban and in goods traffic.

Quite otherwise is the case with regard to

THE MAIN LINE PASSENGER SERVICES

which every year impose augmented duty upon the locomotive. It is not that an increased maximum speed is called for. Very few trains in the Kingdom are timed faster at the present day than was the Great Western express in 1848, and those are all on one Scottish railway, the Caledonian. And the speeds feasible in 1848 with light loads were as high—proportionately to the steam pressure—as any that can be run in 1899. All faster speeds run lately have been done with largely augmented steam pressure. Had mere swiftness alone been the desideratum those famous broad-gauge 8 ft. single-wheelers, which Sir Daniel Gooch first introduced in 1846, would have only needed to be given modern steam pressure to be equal to every requirement. But the *crux* of modern locomotive designers is the huge loads which so often have to be hauled at these high speeds. A Great Western express fifty years ago weighed only from 40 to 60 tons behind the tender—that is to say exclusive of engine and tender. A modern express weighs from 200 to 350 tons behind the tender, and the tender itself, when the water-trough and pick-up scoop are not used, weighs 40 to 45 tons instead of 15 to 25.

Manifestly, then, the present demand upon locomotive designers is for an engine that will pull modern loads at the highest possible speeds, and will perform this duty with as much economy as is practicable under existing conditions. The requirement last-named raises the question of compounding as applied to locomotives, but I may take this opportunity of saying that I find it more convenient to treat



MOST RECENT TYPE OF GREAT WESTERN EXPRESS ENGINE; CYLINDERS 18×26; COUPLED WHEELS 6 FT. 8 IN. SERVE TUBES. STEAM PRESSURE 180 LBS. (M. W. DEAN.)

that point by itself in a separate article, and that my remarks on the present occasion will be confined to engines of non-compound types.

Naturally, the first question which arises is :—

TO WHAT EXTENT DOES THE SINGLE-DRIVER SYSTEM ACCOMMODATE ITSELF TO MODERN NEEDS IN THE WAY OF HAULAGE, ITS SPEED CAPACITY BEING INDISPUTABLE?

To this problem I have devoted a great deal of experimental observation, and I have at last arrived at a definite conclusion. That "single" engines run with greater ease and freedom than do coupled ones, and that, conditions being equal, they possess superior economy in respect of fuel-consumption and repairs is, I think, undeniable and is, I believe, generally admitted. Further, when the circumstances of weather and road are favourable, the single-wheelers can and do run heavy expresses at high speeds with complete success. Sometimes, too, they display remarkable efficiency in taking heavy and fast expresses up fairly steep gradients. On services where the speed is high, the road easy, and the load moderate, the single-wheeler is an ideal express engine. For much of the Great Western, Great Eastern, Midland, Great Central, London & North-Western, Great Northern, and North-Eastern work, no more suitable locomotive could possibly be conceived. And so we find that the three first-named of these lines have just completed a batch of new singles, while the Great Northern has brought out a novel design of single-wheeler; the Great Central is preparing to do likewise, and is making large and beneficial use of the formerly-built singles which it still possesses; as are also the London & North-Western and the North-Eastern.

Nevertheless, it is equally undeniable that when the conditions are adverse the single-wheeler is untrustworthy. That is its sole drawback. But it is obviously a serious one. The tendency of the single-driving wheel to slip is insuperable. It has no doubt been minimised by the sand-blast, which projects a jet of fine sand beneath the tread of the wheel, and with the aid of this useful appliance a single-driver engine can tackle loads and gradients which in its absence would have meant inevitable "stalling." Nevertheless, even this valuable adjunct cannot wholly overcome that fatal weakness, nor can it practically be employed even to mitigate the imperceptible slipping which always goes on in some degree with a single-wheeler, causing the engine to make an appreciable excess of revolutions for every mile covered.

My own experience shows me that a "single" may run a fast and heavy express irreproachably for many days together, and then may be beaten by a side gale or greasy rail to the extent of losing a considerable amount of time. It naturally follows, too, from the circumstances of the case, that when once a single-wheeler is overpowered either by the weight of the train or by either of the adverse conditions just named—overpowered, I mean, in the sense of being unable to keep time—the loss is greater proportionately than with a coupled locomotive. As an illustration, I may instance the case of a Great Northern 7 ft. 6 in. single which took a load of 230 tons from Peterborough to York, 112 miles, in 120½ minutes. Another engine of the same class took 19 minutes longer over the same distance with an addition of 30 tons of load and with a side wind. Or, to take another case, a North-Eastern 7 ft. 6 in. single took 291 tons from York to Darlington, 44¼ miles, in 48½ minutes; another took 54¼ minutes with only 195 tons. Such illustrations could be multiplied. I do not say that coupled engines never give discrepant results. But I do say that this degree of uncertainty and occasional untrustworthiness is distinctly greater in the case of single-wheelers.

Clearly, then, the larger favour enjoyed by the coupled type for heavy express duty is justified by results. And so it is to the coupled express engine that we must look for

THE MOST IMPORTANT RECENT DEVELOPMENTS IN LOCOMOTIVE PRACTICE,

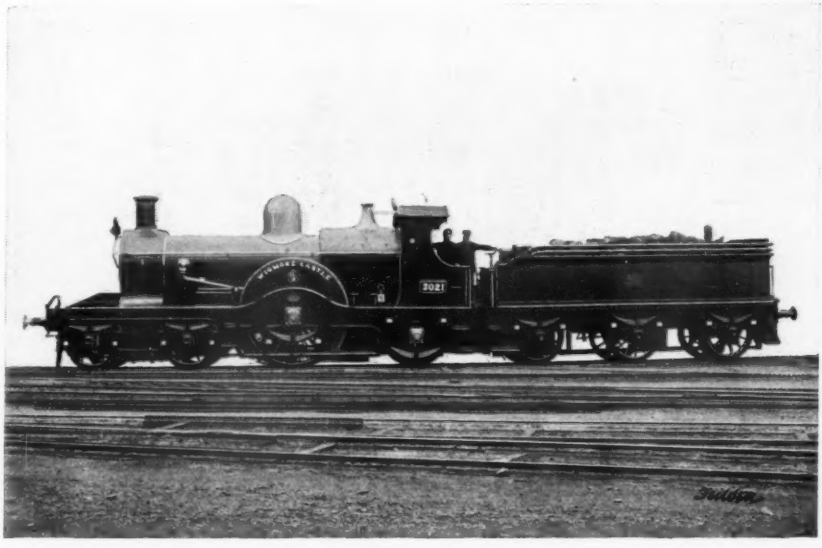
it being borne in mind that the question of compounding is excluded from my present consideration. At the same time, it must not be supposed that the "single" engine

has no sphere of usefulness because it cannot vie with the coupled type in fulfilling the modern requirements of heavy express duty. Its defect is that it cannot be treated like the coupled engine, as a "servant-of-all-work." But when put to the special class of work which suits its capacity, it performs that work with distinctly superior efficiency and economy as compared with a coupled engine. Here again the cases of certain expresses on the Great Western, Great Eastern, Great Northern, and Midland may be pointedly instanced.

Thus, then, we arrive at one very notable characteristic of recent locomotive engineering, the classification of types for particular duty. The tendency is to recognise more and more that single-wheelers should not be regarded as interchangeable with coupled engines, but should be put and, so far as possible, kept to that class of work which experience has demonstrated them to execute most efficiently and economically.

This is recognised very clearly on the Great Eastern and Great Northern lines, which always have used some single-driver engines; by the Great Western, which hitherto has done likewise, but which is understood to contemplate building no more after the batch of eighty now just completed; by the Midland, which resumed the use of "singles" after dropping them for more than twenty years, and still constructs and develops them; and by the Great Central, which, after discontinuing them for sixteen years, is now about to reintroduce them in an improved type for special work. Thus there is no symptom of the single-wheeler becoming extinct or relegated to repose on a pedestal as a relic of an ignorant past. But "singles" will generally be kept henceforth to particular duty expressly adapted to their capacity and limitations.

This system of classification, however, is not confined to the allocation of "single" and "coupled" engines to

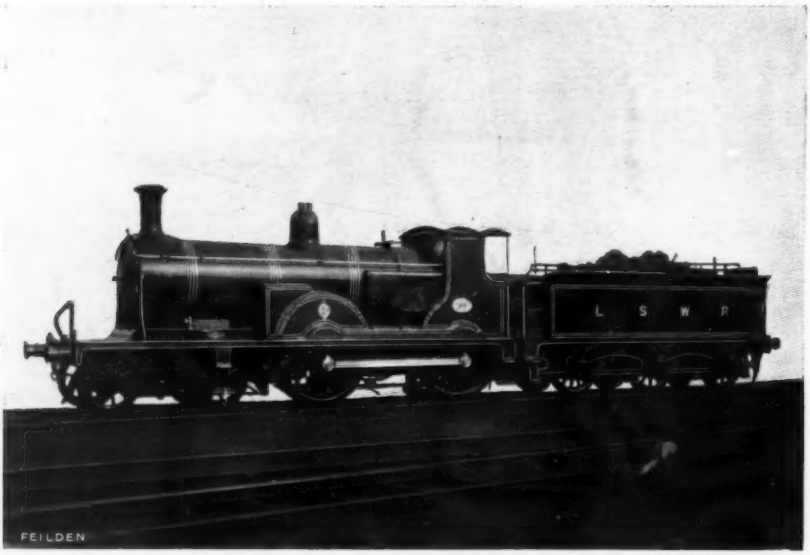


LATEST TYPE OF SINGLE EXPRESS ENGINE, GREAT WESTERN RAILWAY. CYLINDERS 19 × 24; DRIVING WHEELS, 7 FT. 8 IN.; HEATING SURFACE, 1561 SQ. FT.; PRESSURE, 160 LBS. (MR. W. DEAN.)

duties respectively suitable. It extends to

THE DIFFERENT CLASSES OF COUPLED ENGINES

themselves. For the Great Western main line work not allotted to the 7 ft. 8 in. have 6 ft. 8 in. coupled wheels. The two other classes at present consist of a solitary engine each, one of the "Badminton" and one of the "Cornwall" set being fitted with an extra large boiler. Virtu-



MOST RECENT TYPE OF LONDON AND SOUTH-WESTERN EXPRESS ENGINE. CYLINDERS, 18½ × 26; COUPLED WHEELS, 6 FT. 7 IN.; WATER TUBE FIREBOX. STEAM PRESSURE, 175 LBS. (MR. D. DRUMMOND.)

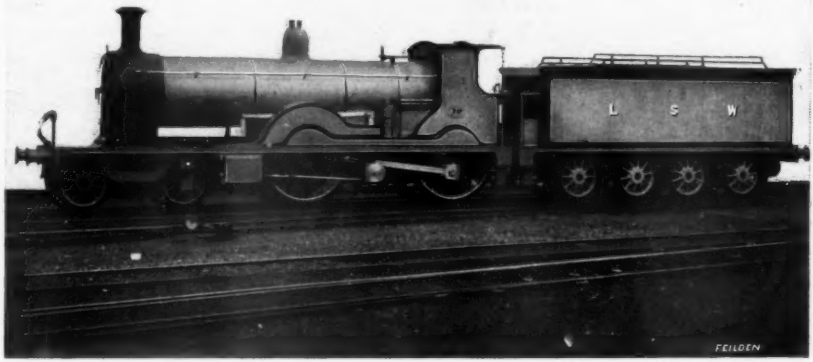
single-wheelers, as many as six—or I might even say eight—different classes of locomotives have been built in recent times. Three of these are non-bogie engines, and have coupled wheels respectively 6 ft. 6 in., 6 ft., and 5 ft. in diameter, the last being the smallest ever used in modern days for express duty. But these were employed on the severe gradients, *e.g.*, 1 in 40, of the Devon and Cornwall main line. They have since been superseded by the "Duke of Cornwall" class, which have 5 ft. 6 in. driving wheels and leading bogies. On the other hand, the 6 ft. engines, as also four large 7 ft. coupled, which were experimentally constructed, are now being replaced on the Severn tunnel expresses by locomotives of the "Badminton" type, which

ally, however, the Great Western practice is resolving itself into these two main coupled types, the smaller wheels being employed on the heavier roads.

A similar system is to be found on the London & South-Western, where engines with 7 ft., 6 ft. 6 in., and 6 ft. coupled wheels are provided for particular classes of service. Thus, the 7 ft. engines are used on the fastest expresses between London and Bournemouth and London and Salisbury, while the 6 ft. 6 in. are employed on the steeper grades west of Salisbury, and the 6 ft. on the heavy stopping and semi-fast trains, also on fast goods trains. In like circumstances, the Great Eastern uses 7 ft. and 5 ft. 8 in. coupled engines, and the Great Northern 6 ft. 6 in. and 5 ft. 6 in; the Midland

7 ft. and 6 ft. 6 in.; the Lancashire and Yorkshire 7 ft. 3 in. and 6 ft.; the North British 6 ft. 6 in. and 5 ft. 6 in., and so on.

But on the other hand, several British main lines which have a prevalent similarity of grades, have deemed it better to act on the "servant-of-all-work" principle, and to build one individual type of engine for all their main line work. I may instance the case of the London, Brighton & South Coast line, which, in the earlier days of the late Mr. W. Stroudley, proceeded strictly on the plan of classification previously referred to, building 6 ft. 6 in. singles, 6 ft. 6 in. coupled, and 5 ft. 6 in. coupled for various classes of traffic, but which in the later days of that eminent engineer, constructed one type only, the well-known "Gladstone," for every kind of main line duty. This course is followed by Mr. Stroudley's successor, Mr. F. J. Billinton, who builds only one class of 6 ft. 9 in. coupled bogie-engines for his main line trains. So, also, on the South-Eastern and London, Chatham & Dover, only one type has been built for many years past, a 7 ft. coupled in the former case, 6 ft. 6 in. in the latter. Also, on the North-Eastern, apart from some casual experiments, the sole main line passenger engines constructed by Mr. Wilson Worsdell are 7 ft. coupled. On the Caledonian, all the pas senger tender-engines built by Mr. J. F. M'Intosh, are virtually one type of 6 ft. 6 in. coupled. And on the Great Central, Mr. H. Pollitt has found one class of 7 ft. coupled sufficient for all varieties of work. In this last case, however, as I have already mentioned, the prevalent tendency is about to prevail, as some large single-wheelers will shortly be placed on the road for the London traffic; and on the North-Eastern



FOUR-CYLINDER EXPRESS ENGINE, LONDON AND SOUTH-WESTERN. CYLINDERS (4), 15 × 26; DRIVING WHEELS (4), 6 FT. 7 IN.; WATER-TUBE FIREBOX; HEATING SURFACE, 1750 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. D. DRUMMOND.

A NEW TYPE OF EXPRESS LOCOMOTIVE,

to which I shall refer later, is about to be introduced for a particular service, thus bringing that railway into line with the rest in the general tendency.

With the two non-compound engines built respectively by Mr. D. Drummond for the London & South-Western, and by Mr. J. Manson for the Glasgow & South-Western, I shall deal more fully, as well as with compound locomotives, in a future article, this latter class, by the bye, including all the passenger engines constructed for the premier British line, the London & North-Western, in recent times, *i.e.* during the past seventeen years.

The main principle which governs the recent characteristics of British locomotive engineering in respect of general design having now been considered, the next step is to review the subject in fuller detail.

In limine, I may observe that pervading all the new departures of the last few years there has been one predominant aim, that of obtaining increased power so as to enable the steadily growing loads hauled at high speeds to be adequately grappled with. Various devices have been resorted to with this object. In some cases the cylinder-diameter has been enlarged, usually by half-an-inch at a time, as in the Midland engines to which Mr. S. W. Johnson has successively given 17 in., 17½ in., 18 in., 18½ in., 19 in., and 19½ in. cylinders. In other instances the piston stroke has been lengthened, *e.g.* from 24 in. to 25 in. and 26 in. on the Great Eastern; from 24 in. to 26 in. on the Midland; from 24 in. to 28 in. on the Great Northern. A third plan has been to reduce the driving-wheel diameter as from 7 ft. to 6 ft. 8 in. on the Great Western; to 6 ft. 6 in. on the London & South-Western; to 6 ft. 6 in. and 6 ft. 9 in. on the Midland; to 6 ft. 6 in. on the North British.

Each of these methods manifestly gives, *per se*, augmented tractive force, adopting the accepted formula that the square of one cylinder multiplied by the length of the piston-stroke and divided by the diameter of one driving-wheel, all in inches, will give the tractive force in lbs. to every lb. of effective steam pressure in the cylinders. It follows therefore, *primâ facie*, that the larger you make the cylinder, the longer the piston-stroke and the smaller the driving-wheel, the more you augment the tractive force of the engine. But experience has shown that this theory is conditioned in a very large degree by qualifying circumstances. It is a moot point to

WHAT EXTENT HIGH PISTON SPEED IS ADVANTAGEOUS.

At one time the longing for a good formula in round numbers which so largely pervades the engineering temperament, led a piston-speed of 1,000 ft. per minute to be proposed as a standard limitation. But practice has demonstrated that it is feasible and often advantageous to employ a much higher piston-velocity. For one thing, a sharper blast is obtained. On the other hand, there is a manifest drawback in any needless multiplication of the frequency with which the cylinders have to be filled and emptied and of the movements made by the reciprocating parts. The former involves larger steam-use and enhanced back-pressure, the latter increased strain and friction and wear-and-tear of the working parts. Both mean augmented resistance.

So a sort of compromise has been reached by general consent. As *ceteris paribus* the smaller the driving-wheel the higher the piston-speed, it has been deemed advisable to adopt a moderate diameter for the coupled wheels, and the size in common use for all normal work ranges from 6 ft. 6 in. to 7 ft. It is only in special cases, when lower speeds are contemplated, that it is reduced to 5 ft. 9 in., or 5 ft. 6 in. Similarly while indefinitely augmented length of piston-stroke would give theoretically greater power by leverage, it is found in practice that a length exceeding 26 in. is not desirable, for the same reason that a very small driving-wheel is condemned, viz., as increasing the velocity of the reciprocating parts. Hence the extreme length of 30 in., once employed on the North-Eastern, has long been abandoned and the unusual stroke of 28 in. once used by the Great Northern in coal-engines is now confined to the express locomotives which have single driving-wheels of the exceptional diameter of 8 ft. 1½ in.

Some eminent locomotive engineers, indeed, have adhered persistently to a

piston-stroke of 24 in. Mr. F. W. Webb, on the London & North-Western, has never employed a longer piston-stroke. Nor had the Great Eastern until Mr. J. Holden brought out his latest class of "singles" last year, when he increased it to 26 in. Nor had the Great Western until lately, when Mr. W. Dean introduced the 26-in. stroke in his latest classes of coupled engines. The unique stroke-length of 25 in. is now being adopted by Mr. Holden in rebuilding some of the Great Eastern engines which previously had a 24-in. stroke. But it may be stated definitely that the standard piston-stroke at present employed in Great Britain is one of 26 in.

It may appear a progress in reverse order that I should work backward from the wheels and piston-stroke to the cylinders and boiler. But I have chosen that method deliberately. I have preferred to lead up by steps to

THE MOST IMPORTANT POINTS OF ALL IN RELATION TO POWER AND EFFICIENCY.

I have referred to the method adopted by some designers of steadily expanding their cylinder-diameters in order to gain additional power. It might at first appear that this would be a sure means of attaining their end. But here again the results are qualified by conditions. One of these applies, in practice, to "single" engines alone, namely, that the tractive power should not exceed the weight available for adhesion, otherwise such excess will be wasted and only slipping of the wheels will result. This condition has been modified from time to time, first by increasing the weight on the driving wheels; second, by the use of the Gresham sand-blast. The former plan has been developed until the weight of 15 tons, which, twenty-five years ago, when the rails were lighter, was deemed the maximum permissible upon any one pair of wheels,

LIQUID-FUEL-BURNING EXPRESS ENGINE, GREAT EASTERN. CYLINDERS, 18 × 26; DRIVING WHEELS, 7 FT.; HEATING SURFACE, 1292 SQ. FT.; STEAM PRESSURE, 160 LBS. (MR. J. HOLDEN.

has swelled with increasingly heavy rails, to 16, 17, 18, 19, 20, and even 21 tons. The last 8 ft. "singles," built by the late Mr. Patrick Stirling, had originally 20 tons on the drivers; so had Mr. Dean's 7 ft. 8 in. single-wheelers on the Great Western. But it was found advisable, I believe, to reduce the weight in each case by a ton. I gathered from the late Mr. C. Sacré that the weight on the drivers of his 7 ft. 6 in. Great Central singles was originally as much as 21 tons, and I understand that this is also the case with the 7 ft. 6 in. North-Eastern "singles," as rebuilt by Mr. W. Worsdell. As a rule, however, it may be accepted as the most recent locomotive practice in this country that the weight on a single axle shall not exceed 18 to 19 tons. That is, therefore, in such case, the aggregate of the weight available for adhesion. Any tractive force applied that is more than equivalent to the weight will simply produce slipping and not progress.

But it is no uncommon thing to find a

SINGLE-DRIVER LOCOMOTIVE SLIPPING BADLY,

even when the tractive force exerted by the piston is much below the equivalent of the weight actually resting on the driving axle. Indeed, it is seldom that more than a fourth of this actual weight is effectively available in practice, and far oftener only a fifth, or on a greasy rail a sixth, is really available for purposes of traction. Much of this loss previously sustained is now, however, saved by the use of the sand-blast, which, in ordinary working, if judiciously applied, enables a far larger proportion of the available adhesion weight to be profitably utilised. It is true that surprisingly good results were often obtained with the Great Northern, Great Eastern, and Great Western "singles" without the aid of this valuable appliance, but it is quite certain that the capacity of those engines has been enormously developed with its assistance, and that the birth of an army of splendid single-wheelers on the Midland and of several on the North-Eastern, subsequent to its introduction, would never have taken place had this accessory been lacking.

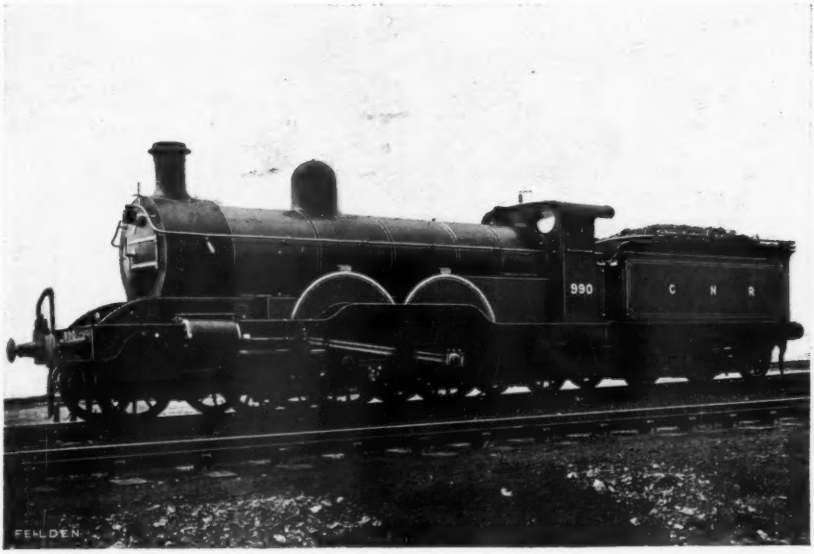
There is another condition even more important which qualifies the value of larger cylinders. And here we reach

THE FOUNTAIN-HEAD OF THE WHOLE MATTER.

It is obviously useless to provide a large cylinder unless you also supply sufficient steam to fill it. Or, to put the case with more precision, a large cylinder is only useful when it is kept constantly supplied with enough steam to keep it working under its most favourable conditions of operation.

Unfortunately, this axiomatic fact opens up a wide area of divergence in opinion as to its application. It has been held that there is an economic advantage in limiting the steam supply—I might almost put it, in keeping the cylinders short of steam—because this, theoretically, compels the driver to use his steam more expansively, and therefore economically. Unluckily this idea, while extremely pretty in theory, has broken down utterly in practice. When the ideal driver shall have been invented—or bred—in whom the element of personal equation does not exist; who is always able to judge exactly how much steam he can profitably use without running his boiler out of breath, and when that ideal driver shall be fitted with a perfect engine, with precisely his proper train-load, and with a line free from gradients and slippery rails, then this ideal system may work in practice. Hitherto none of the essential conditions have been forthcoming, and so the engines have run short of steam. Not only the cylinder, but also all demands upon it, must bear a just proportion to the power behind, which is located in the boiler, else the engine will fail if put to work of the highest class.

A notable instance of disparity in this respect has always been furnished by the 6 ft. 6 in. coupled engines built by the late Mr. Patrick Stirling. These engines do well enough on light fast expresses, or heavy stopping trains, or goods trains, but when put on a fast and heavy express, they invariably lose time because they are short of steam, having only 916 sq. ft. of heating surface to cylinders $17\frac{1}{2} \times 26$. The result could not well be otherwise in



TEN-WHEELED EXPRESS ENGINE, GREAT NORTHERN. CYLINDERS, 19 × 24; COUPLED WHEELS, 6 FT. 7 IN.; HEATING SURFACE, 1440 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. H. A. IVATT.)

MOST RECENT TYPE OF GREAT NORTHERN SINGLE-WHEEL EXPRESS ENGINE. CYLINDERS, 18 × 26; DRIVING WHEELS, 7 FT. 7 IN.; HEATING SURFACE, 1268 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. H. A. IVATT.)

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But it is no uncommon thing to find a

SINGLE-DRIVER LOCOMOTIVE SLIPPING BADLY,

even when the tractive force exerted by the piston is much below the equivalent of the weight actually resting on the driving axle. Indeed, it is seldom that more than a fourth of this actual weight is effectively available in practice, and far oftener only a fifth, or on a greasy rail a sixth, is really available for purposes of traction. Much of this loss previously sustained is now, however, saved by the use of the sand-blast, which, in ordinary working, if judiciously applied, enables a far larger proportion of the available adhesion weight to be profitably utilised. It is true that surprisingly good results were often obtained with the Great Northern, Great Eastern, and Great Western "singles" without the aid of this valuable appliance, but it is quite certain that the capacity of those engines has been enormously developed with its assistance, and that the birth of an army of splendid single-wheelers on the Midland and of several on the North-Eastern, subsequent to its introduction, would never have taken place had this accessory been lacking.

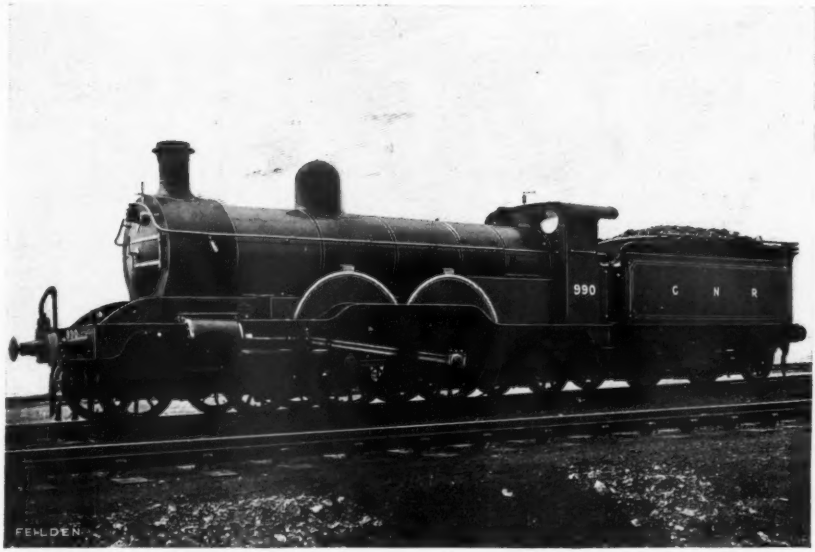
There is another condition even more important which qualifies the value of larger cylinders. And here we reach

THE FOUNTAIN-HEAD OF THE WHOLE MATTER.

It is obviously useless to provide a large cylinder unless you also supply sufficient steam to fill it. Or, to put the case with more precision, a large cylinder is only useful when it is kept constantly supplied with enough steam to keep it working under its most favourable conditions of operation.

Unfortunately, this axiomatic fact opens up a wide area of divergence in opinion as to its application. It has been held that there is an economic advantage in limiting the steam supply—I might almost put it, in keeping the cylinders short of steam—because this, theoretically, compels the driver to use his steam more expansively, and therefore economically. Unluckily this idea, while extremely pretty in theory, has broken down utterly in practice. When the ideal driver shall have been invented—or bred—in whom the element of personal equation does not exist; who is always able to judge exactly how much steam he can profitably use without running his boiler out of breath, and when that ideal driver shall be fitted with a perfect engine, with precisely his proper train-load, and with a line free from gradients and slippery rails, then this ideal system may work in practice. Hitherto none of the essential conditions have been forthcoming, and so the engines have run short of steam. Not only the cylinder, but also all demands upon it, must bear a just proportion to the power behind, which is located in the boiler, else the engine will fail if put to work of the highest class.

A notable instance of disparity in this respect has always been furnished by the 6 ft. 6 in. coupled engines built by the late Mr. Patrick Stirling. These engines do well enough on light fast expresses, or heavy stopping trains, or goods trains, but when put on a fast and heavy express, they invariably lose time because they are short of steam, having only 916 sq. ft. of heating surface to cylinders $17\frac{1}{2} \times 26$. The result could not well be otherwise in



TEN-WHEELED EXPRESS ENGINE, GREAT NORTHERN. CYLINDERS, 19 × 24; COUPLED WHEELS, 6 FT. 7 IN.; HEATING SURFACE, 1440 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. H. A. IVATT.)

MOST RECENT TYPE OF GREAT NORTHERN SINGLE-WHEEL EXPRESS ENGINE. CYLINDERS, 18 × 26; DRIVING WHEELS, 7 FT. 7 IN.; HEATING SURFACE, 1268 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. H. A. IVATT.)

such circumstances. Mr. Stirling's successor, Mr. H. A. Ivatt, while building locomotives otherwise of the same class and nominal force, has given them greatly enlarged boilers, with most favourable results.

Two still more

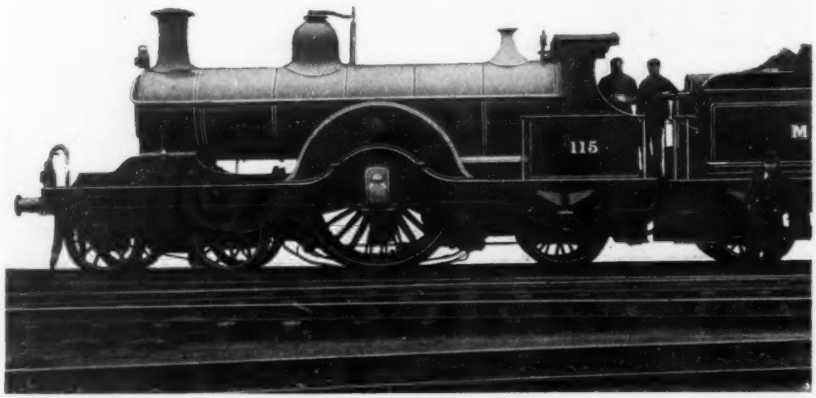
RECENT AND PROMINENT ILLUSTRATIONS

of this salient principle in locomotive engineering may be found in the experiments tried by Mr. F. W. Webb with his four-cylinder non-compound engine, "Iron Duke," and by Mr. D. Drummond with his four-cylinder non-compound No. 720. In the former, a boiler having 1,400 sq. ft. of heating surface was set to fill four 15 in. cylinders. Experience showed that the engine could not "maintain herself" when supplying that quantity of "live" steam, while hauling heavy expresses at high speed. And Mr. Drummond similarly found that even his larger boiler, supplemented by water-tubes in the fire-box, and giving 1,750 sq. ft. of heating surface in all, could not keep her four 16½ in. high pressure cylinders going in full ordinary work, and they had to be lined up to 15 in. Even when thus reduced, the boiler had all its work cut out.

Upon no question does greater difference of opinion prevail among British locomotive engineers than regarding the

PROPER AMOUNT OF HEATING-SURFACE

and its disposal. At the present moment the point seems no nearer settlement than ever. But at least we do seem to have outgrown the archaic notion that 900 to 1,200 sq. ft. of heating-surface could be made to suffice for the haulage, unaided, of modern expresses at modern speeds. It is remarkable that so long ago as 1847



LATEST TYPE OF SINGLE EXPRESS ENGINE, MIDLAND RAILWAY. CYLINDERS, 19½×26; DRIVING WHEELS, 7 FT. 9 IN.; STEAM PRESSURE, 170 LBS.; HEATING SURFACE, 1233 SQ. FT. (MR. S. W. JOHNSON.)

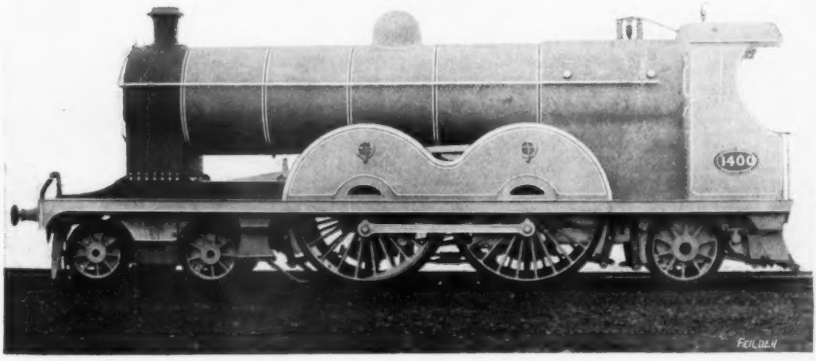
so "Iron Duke" was converted into the four-cylinder compound "Jubilee," which I shall refer to in my second article. Sir Daniel (then Mr.) Gooch gave his famous broad-gauge engines 1,952 sq. ft. of heating-surface, and in 1853 Mr. Archi-

ERRATUM.

Page 31. Inscription at foot of illustration (Lancashire and Yorkshire Express Engine):—

Read 2,052 sq. ft. heating surface, *instead of* 1,052 sq. ft.

bald Sturrock gave his Great Northern 7 ft. 6 in. "single" 1,718 sq. ft. Yet Mr. Patrick Stirling gave his latest 8 ft. has largely had its rise in the splendid results achieved both on the Caledonian Railway of Scotland and on the Northern



NEW TEN-WHEELED EXPRESS ENGINE, LANCASHIRE AND YORKSHIRE RAILWAY. CYLINDERS, 19 × 26; COUPLED WHEELS, 7 FT.; STEAM PRESSURE, 175 LBS; HEATING SURFACE, 1052 SQ. FT. (MR. J. ASPINALL.)

singles, built in 1895, only 1,031 sq. ft., and his brother, Mr. J. Stirling, up to last year, had only 1,020 sq. ft. in his fine 7 ft. coupled South-Eastern engines. The latter, it is true, are not required to attain the highest speeds, but the Great Northern engines are called upon habitually to run with very heavy loads at the fastest speeds known, and as a rule they do it admirably, although cases undoubtedly do arise, and that not seldom, when their need of greater boiler power is unpleasantly manifested. In Mr. Ivatt's new type of Great Northern "single," No. 266, and in Mr. J. Stirling's latest South-Eastern 7 ft. coupled, "440" class, far larger boiler-power is wisely provided, and with signal advantage.

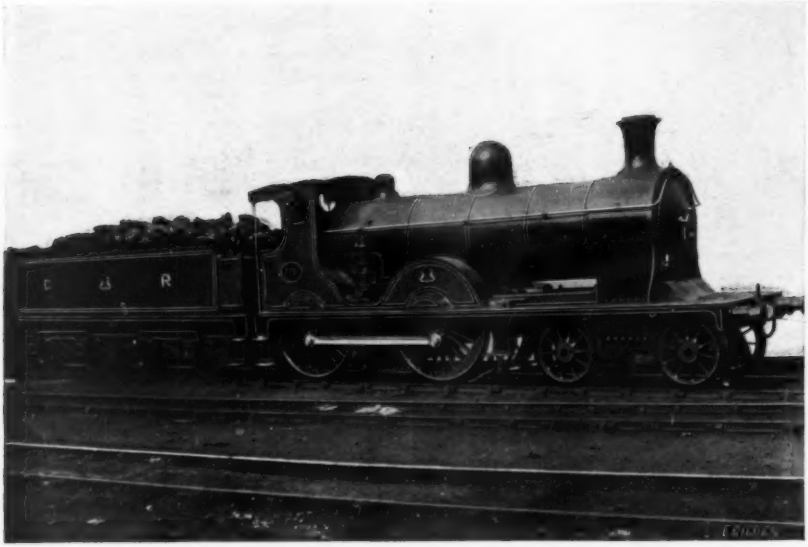
That there is throughout these islands a general tendency and movement in favour of much larger boilers is undeniable. It

Railway of France, with engines—Mr. J. F. M'Intosh's "Dunalastairs" in the one case, and MM. de Glehn and du Bousquet's four-cylinder compounds in the other—which, while having little, if any, larger nominal tractive power than many other engines now running, possessed the

SPECIAL ADVANTAGE OF VAST BOILERS.

In each of these cases the work performed has been materially in advance of any other that has come under my personal notice in all my large experience, nor have I seen any authentic records of equal work as taken in this country by other observers.

It being made clear that increased boiler-power was needed, most of the leading British engineers have set about supplying it. And so all the most recent



LATEST TYPE OF COUPLED EXPRESS ENGINE, CALEDONIAN RAILWAY. CYLINDERS, 19 × 26; COUPLED WHEELS, 6 FT. 6 IN.; HEATING SURFACE, 1500 SQ. FT.; STEAM PRESSURE, 175 LBS. (MR. J. F. McINTOSH.)

designs show huge boilers. These are pitched very high, experience having demonstrated that this method gives improved steadiness to an engine in running, while it does not necessarily involve elevation of the centre of gravity. Thus we find in Mr. Dean's latest Great Western types—"Waterford" and "Bulldog"—huge boilers of such large diameter and so highly pitched above the 6 ft. 8 in. wheels in the former case, that there is no room for a safety-valve column over the Belpaire fire-box, or for a dome at all, the old Great Western practice of taking the steam from a perforated pipe having to be reverted to. It is difficult to compare the heating surface of these engines with others, as they have the corrugated Serve tubes, which require a special mode of computation, but probably it may be taken as equivalent to 1,500 or 1,600 ft. with the plain tubes. The Serve system is still in its experimental stage here, but on the Continent it is found to work very beneficially, provided the engines are kept at their full power, not otherwise.

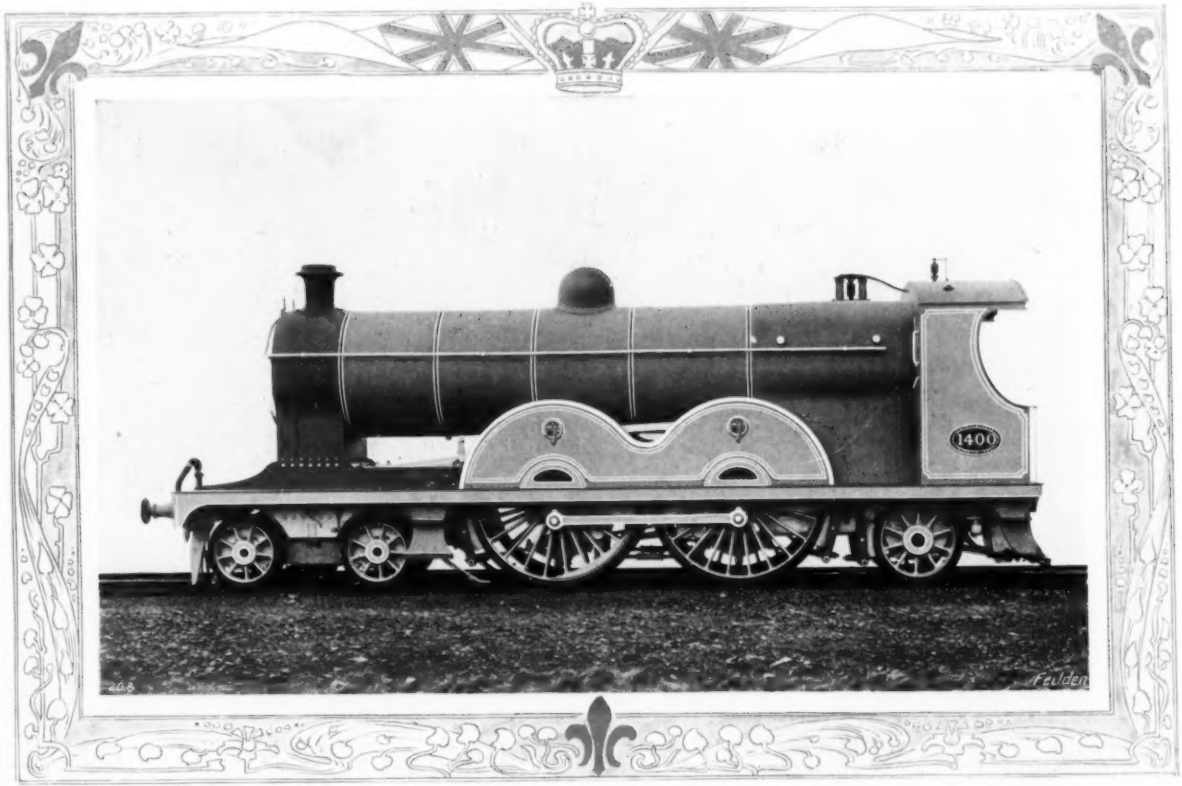
To his "720" type on the London & South-Western, Mr. Drummond has given 1,750 square ft. of heating-surface, with water-tubes in fire-box; Mr. Billinton's "Bessemer" (London, Brighton & South Coast) has 1,460; Mr. J. Holden's (Great Eastern) No. 10 class has 1,292; Mr. Ivatt's (Great Northern) "990," 1,442; Mr. Worsdell's (North-Eastern), "1619," 1,329, with water-tubes in fire-box; Mr. Aspinall's "1,400" (Lancashire and Yorkshire) has 2,052 square ft.; Mr. Holmes' "729" class 1,350; Mr. M'Intosh's Caledonian "Breadalbanes" (enlarged "Dunalastairs") 1,500. Also Mr. S. W. Johnson's new Midland coupled engine will have 1,450 square ft., and Mr. H. Pollitt's new (Great Central) "singles" 1,750.

Here, then, appears

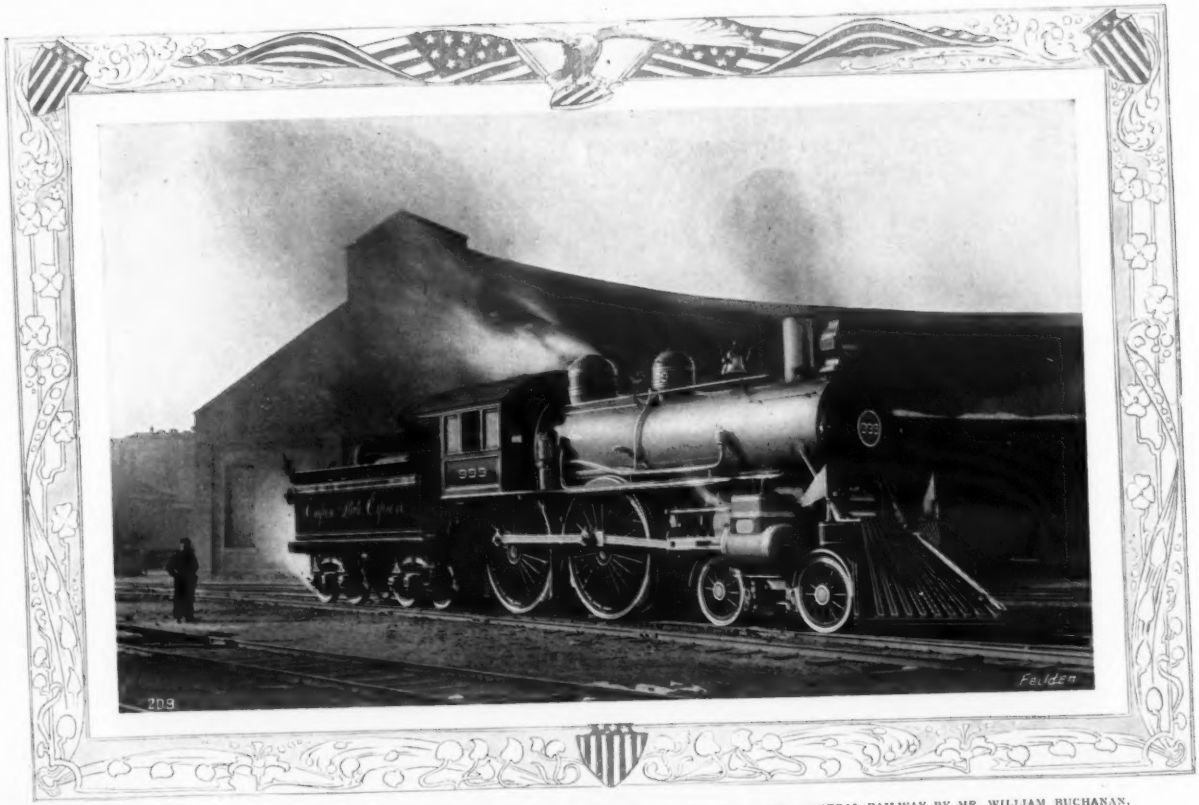
THE MOST IMPORTANT PHASE OF ALL IN RECENT LOCOMOTIVE DESIGNS.

But it must not be imagined that the whole secret of augmenting the boiler-power is discovered when the heating-surface has been enlarged. Far from it.

SUP



NO. 1400.—THE PIONEER OF THE NEW TYPE OF BRITISH HEAVY EXPRESS ENGINES. DESIGNED BY MR. J. A. F. ASPINALL, THE CHIEF MECHANICAL ENGINEER OF THE LANCASHIRE AND YORKSHIRE RAILWAY. SEE PAGE 38.

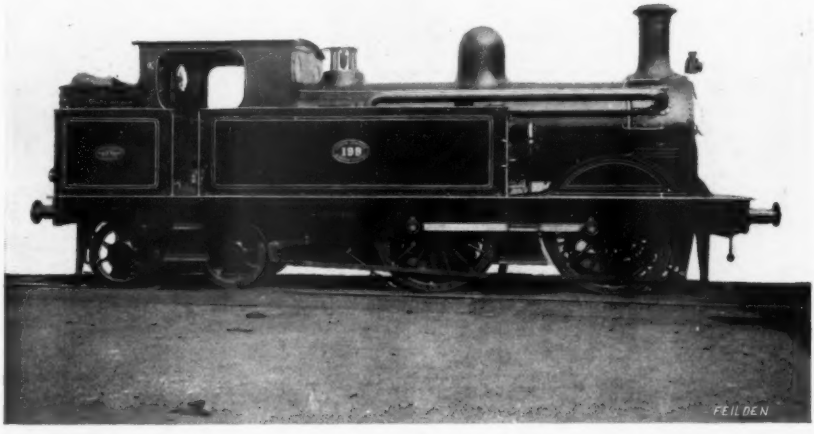


NO. 999.—THE MOST FAMOUS HEAVY EXPRESS ENGINE IN AMERICA, DESIGNED FOR THE NEW YORK CENTRAL RAILWAY BY MR. WILLIAM BUCHANAN, SUPERINTENDENT OF MOTIVE POWER TO THAT LINE. SEE PAGE 38.

Another point on which expert opinion differs widely is the disposal of heating-surface and its proportion to the size of the boiler. One engineer holds that the efficacy of the tubes practically ceases beyond 7 ft. 6 in. from the fire-box. Another considers that he obtains some value throughout their whole length—in that case of 13 ft. or more. One advocates the use of a number of tubes which another condemns as undue crowding, involving loss of benefit. And so in respect of the number as well as of the length and size of tubes which can be most advantageously employed, nothing like a consensus of opinion exists or appears at all likely to arrive. On no point do "doctors differ" more widely and variously.

So also with regard to another point of the utmost moment, the best steam pressure, there is a large diversity of view. Still, in this case the tendency is unmistakable. Just as those who 15 years ago stuck out for 140 lbs. as the highest pressure practically serviceable soon had to come round to the introduction of 160 lbs., so the "160 pounders" have been compelled in their turn, and many even within the past year, to admit that 170, 175, 180, and even 200 lbs. pressure gives in practice far better proportionate results than any lower pressure. Therefore we find 180 lbs. now adopted on the Great Western; 175 lbs. on the London and South-Western, Brighton, Great Eastern, Great Northern, London and North-Western, Midland, North-Eastern, Great Central, Lancashire and Yorkshire, North British and Caledonian; while on the North-Eastern and North-Western 200 lbs. is being tried, and on several Continental lines 213 and even 227 lbs. are used.

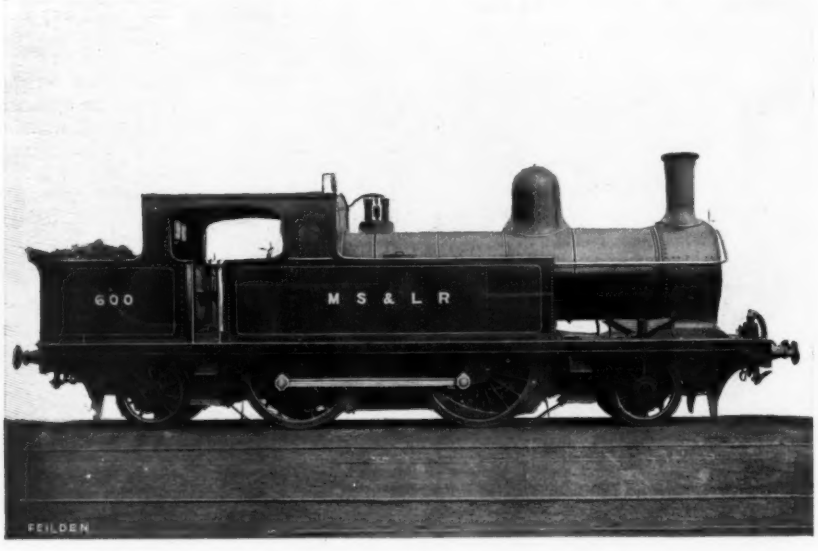
Practical experience has shown that while augmented power may be sought for in other directions, such as cylinder diameter, piston-stroke, or small wheels, if the work demanded be mere haulage at moderate speed, or the climbing of steep gradients, high steam pressure is an essential factor in the attainment of the fastest speeds, especially with heavy loads. The



STANDARD TANK-ENGINE FOR SUBURBAN WORK, LONDON, CHATHAM AND DOVER RAILWAY; TYPE OF ONE CLASS GENERALLY USED THROUGHOUT GREAT BRITAIN. CYLINDERS, 17 × 24; COUPLED WHEELS, 5 FT. 6 IN.; TRAILING BOGIE. (MR. W. KIRTLEY.)

quickness and sharpness of action given by steam of very high pressure is invaluable in such cases. It may justly be said that this tendency to use increased pressure of steam is among the most important of the recent characteristics of locomotive designs. It may be that the old trouble and obstacle of back-pressure is in some degree enhanced, but efforts are being made to overcome this so far as possible, by allowing increased freedom of exhaust, the exhaust-ports being enlarged to as great an extent as the construction of each particular type of locomotive will permit.

steam generation in the place where this is more valuable than anywhere else, viz., above the top of the fire-box. Experiments have ascertained that the steam-generating capacity of a cube of heated iron is enormously greater on its upper surface than on its sides, while that of its under surface is almost *nil*. The Belpaire system, which has now been adopted also by Mr. Dean on the Great Western, and by Mr. Johnson for his new Midland engines, thus affords additional heating-surface of a kind which is worth greatly more than that obtained in any other way.



SECOND TYPE OF STANDARD TANK ENGINE FOR SUBURBAN WORK, MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE (NOW GREAT CENTRAL). CYLINDERS, 18 × 24; COUPLED WHEELS, 5 FT. 6 IN.; LEADING AND TRAILING RADIAL AXLES. (MR. H. POLLITT.)

Another salient feature in recent designs is

THE VAST ENLARGEMENT OF THE FIRE-BOX,

which, in the latest Great Northern type, is given a length of 8 ft., and a heating surface of 140 sq. ft. On the Great Central, Mr. H. Pollitt has long adopted with much advantage the raised Belpaire fire-box, which affords valuable space for

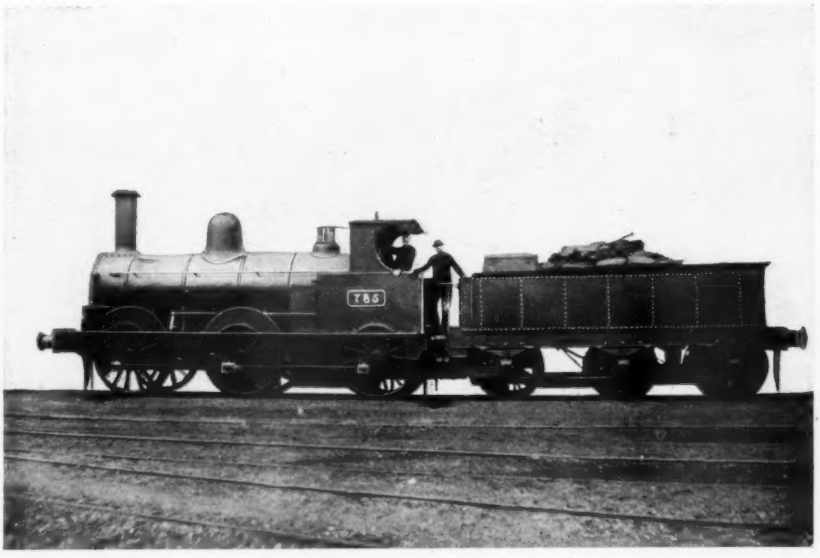
Possibly the use of water-tube fire-boxes—another specialty of recent designs —may prove to be an equally valuable adjunct to existing means of steam production. It is being tried, as I have already mentioned, by Mr. Drummond on the London & South-Western, and by Mr. Worsdell on the North-Eastern, but as yet sufficient data are not available to enable any definite conclusion to be

arrived at as to the practical value of the plan. That it is useful as an aid to steam production seems unquestionable, but in some instances serious trouble has been experienced in keeping the water-tubes which pass through the fire-box thoroughly steam-tight and water-tight, and it will readily be understood that their leakage in such a position would be a more than ordinarily awkward mishap. So the point must be left for further experience to settle.

In order to obtain abundance of steam, it is obvious that free combustion of the fuel is essential. Some of our leading engineers hold that hitherto the fire-grates used have been of insufficient area, 16 to 18 sq. ft. being a space commonly employed. And so in some of the newest engines, we find as much as 23 to 26 sq. ft. of grate area provided, with palpable advantage in respect of free combustion.

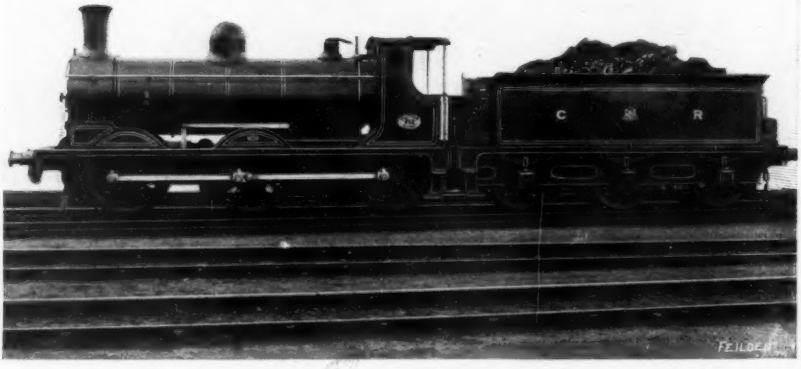
THE QUESTION OF INSIDE versus OUTSIDE CYLINDERS

can hardly be deemed any longer one of "practical politics" in Great Britain. Absolute unanimity now prevails throughout the leading railways of these islands —about the only point, I believe, on which such a consensus exists — and that, strangely enough, is diametrically opposed to the almost invariable practice on the Continents of Europe and America. The British decision is unanimously against outside cylinders unless these should be necessitated by a special construction of locomotive. Thus, to take the exceptions, they are inevitable in the cases of the four-cylinder engines designed by Messrs. Drummond and Webb, and also by Mr. J. Manson, in the last named case for the Glasgow and South-Western line. So they are in Mr. Ivatt's ten-wheeled Great Northern engine, because it is a feature of its design that the two pairs of 6 ft. 6 in. coupled wheels shall be placed close together under the middle of the boiler, and that the rear pair shall be the drivers, so as



STANDARD GOODS ENGINE, LONDON AND NORTH-WESTERN RAILWAY D. C. CLASS; VIRTUAL PROTOTYPE OF ALL MODERN GOODS ENGINES. CYLINDERS, 16 × 24; COUPLED WHEELS, 5 FT. (MR. J. RAMSBOTTOM.)

to give increased length of connecting-rod with a minimum length of coupling-rod. But all the engines of the ordinary types are now designed with inside cylinders. This system is preferred as giving a steadier motion under the middle of the boiler, while the cylinders are in a warmer situation, protected from the chill of the outer air, with its consequence of condensation. The formerly-alleged weakness of the double-web crank axle is denied in these days, provided the axle be properly constructed, and it is even contended that the straight axle is more liable to fracture



MODERN STANDARD GOODS ENGINE, CALEDONIAN. CYLINDERS, 18 × 26; COUPLED WHEELS, 5 FT.
(MR. J. F. McINTOSH.)

because it is subjected to the strain of torsion at its extreme ends; also, the "punching," or "boxing," motion set up by outside cylinders is rougher and less even than the directer middle-line pull of inside cylinders, while the exposure of the outside cylinder to cold air, involving liability to condensation, is of course indisputable.

STEAM-JACKETING

has been suggested as a remedy for this last drawback of outside cylinders, and may perhaps be ultimately adopted in those new engines whose peculiarity of design compels the use of the outside position. But the prevalent tendency is to abolish outside cylinders altogether. The plan of steam-jacketing is being tried by Mr. J. A. F. Aspinall with the inside cylinders of his gigantic new "1400" class, and of some of his older engines, and his experience is that the equivalent of an additional half-inch of cylinder diameter is gained even when the inside position is adopted. Manifestly the gain should be still greater with steam-jacketed outside cylinders, but some high authorities hold a different view. This point, too, can only be determined by experiment and experience.

Another point on which the opinion of British locomotive engineers now approaches closely to unanimity, as has long been the case in Europe and America, is in favour of taking the steam from a dome, rather than from a

perforated pipe. In this case British opinion now agrees with that of Europe and America. With the death of Mr. P. Stirling and the retirement of his brother, Mr. J. Stirling, the last two eminent advocates of the perforated pipe have gone and the dome promises to be virtually universal in these islands. It is being fitted to all Great Northern engines as they come in for rebuilding, and has long replaced the perforated pipe on the Great Western where the latter was almost always employed during the reign of Sir D. Gooch and Mr. Armstrong. But it is curious that in the case of the newest Great Western locomotive, Mr. Dean has been obliged to revert to the perforated pipe owing to there being no room for a dome over the exceptionally high-pitched boiler.

Yet one more matter as to which opinion appears to be nearing a consensus, is as to

THE USE OF A FOUR-WHEELED BOGIE UNDER THE LEADING END OF EXPRESS ENGINES.

During the past two years every express engine that has been built in this country has been furnished with this valuable appliance, and with unmistakable advantage. The Great Eastern was the last to build express engines with a single pair of leading wheels, but the newest Great Eastern engines have leading bogies and run all the better for the improvement.

As

THE LIQUID-FUEL QUESTION

is one which stands alone, and as, moreover, the use of liquid-fuel is at present practically confined to a single line—the Great Eastern, where Mr. J. Holden's admirable method is largely employed—it is not convenient to discuss it in an article of a more general character. Nor do I deem it advisable to enter upon the moot points of piston-valves and piston tail-rods. Each is being experimentally tried on various railways, but, so far, the results do not seem to me sufficiently conclusive to warrant any definite judgment as to their value.

I have now passed in review the salient features in the recent characteristics of locomotive engineering in Great Britain, with the exception of the question of compounding, which I reserve for a second article. I do not now review at any length the four-cylinder non-compound system, or the ten-wheeled variety of express locomotive. My reason is that both of these methods are still in the stage of trial, and no tendency toward the general adoption of either plan can be accurately included among the recent characteristics of British locomotive-engineering. Upon the former, in relation to the question of compounding, I shall touch in a future article. But a few words in conclusion about the ten-wheeled express engines that are now beginning to make their appearance may be found interesting.

So far, the

TEN-WHEELED TYPES

actually out are only two in number. Mr. H. A. Ivatt's No. 990 on the Great Northern was the pioneer. This engine, which weighs 58 tons, has a boiler of exceptional dimensions, viz., length 14 ft. 8 in., diameter 4 ft. 8 in., length of tubes 13 ft., heating-surface 1,442 sq. ft., of which the fire-box gives 140 ft.; the fire-grate area is 26·75 sq. ft., and the steam pressure 175 lbs.; cylinders (outside) 19 × 24; coupled wheels 6 ft. 6 in. The general design and arrangements will be gathered from the accompanying illustration. Mr. J. A. F. Aspinall's No. 1,400, on the Lancashire and Yorkshire, is a very recent arrival. It presents an even more gigantic appearance, and weighs 15 cwt. more than the Great Northern No. 990. It also has a 2 in. longer piston-stroke, and 9 in. larger coupled wheels, while the cylinders are inside instead of outside, and the boiler has the following remarkable dimensions—wholly unprecedented in this country:—Length (tubes) 15 ft., diameter 4 ft. 10 in., heating-surface 2,052 sq. ft., of which the fire-box provides 175 ft., fire-grate area 26 ft., steam pressure 175 lbs., cylinders 19 × 26, coupled wheels 7 ft. 3 in., weight (engine) 58 tons 15 cwt. Both engines have a very fine and massive appearance, and ought to possess vast power; indeed, this has already been

proved in the case of the Great Northern locomotive; that of the Lancashire and Yorkshire has yet to show what it can do.

The ten-wheelers which Mr. Wilson Worsdell is building for the North-Eastern will have one feature entirely novel in Great Britain as applied to express engines, namely, six coupled wheels. These will be 6 ft. in diameter, and the cylinders will be 20 × 26, with a boiler having about 2,000 sq. ft. of heating-surface and 200 lbs. steam pressure. This, too, will be a most interesting experiment. But, as I have stated, none of these fresh types can yet be said to have obtained permanent acceptance. The illustrations are reproductions of photographs by Mr. F. Moore, of South Place, Finsbury.

C. Rous-Marten

The question of compounding, as exhibited by recent English and Continental practice, will be fully dealt with by Mr. Rous-Marten in a subsequent article in FEILDEN'S MAGAZINE.—ED.

The two engines illustrated in the special supplement to this issue represent the most noteworthy developments of the non-compound locomotive in Great Britain and America respectively. Each has characteristics which may be termed "National," as illustrating the prominent features of design that are preferred on the respective sides of the Atlantic.

"No. 1400" is the pioneer of the new type of heavy express engines designed by Mr. J. A. F. Aspinall, the able chief mechanical engineer of the Lancashire and Yorkshire Railway of England, for the passenger service of that line. Steep gradients and sharp curves prevail very largely on the Lancashire and Yorkshire Railway, while the passenger trains are often of great weight, subject to numerous stoppages, and often required to run at high speeds under difficult and adverse conditions.

To satisfy these requirements Mr. Aspinall designed and built at the Horwich Works of the Company the engine now under notice, which possesses dimensions quite exceptional in British practice, and in some respects unprecedented. The coupled wheels are of the same size as those previously in use under the Standard express engine, viz., 7 ft. 3 in. So are the bogie wheels, 3 ft. So are the cylinders, if compared with that—the "1100"—class, as originally built, viz., 19 in. by 26 in. But the special peculiarity of the new engine consists in the gigantic size of its boiler, which is 15 ft. in length, and 4 ft. 10 in. in diameter. Its centre is 8 ft. 11 in. above the rail level. The firebox is 8 ft. 1 in. long, and has a heating surface of 175 sq. ft., the total heating surface of tubes and box combined being 2,052 sq. ft.—the largest yet seen in British practice. The weight of the engine is 58 tons 15 cwt., of which 35 tons are available for adhesion. The total weight of engine and tender loaded is 89 tons 8 cwt. For the rest, "No. 1400" has the inside cylinders, plate frames, and other constructive methods which are customary in British practice.

"No. 999," perhaps the most famous and widely-known express engine yet produced in America, was designed for the New York Central Railway by Mr. William Buchanan, the eminent superintendent of motive power to that line. It is of the standard type employed in the United States, and known as the "American," having driving and trailing wheels coupled, leading four-wheeled bogie and outside cylinders. The coupled wheels are 7 ft. 2 in. in diameter; the bogie wheels 3 ft. 4 in. The cylinders are 19 in. × 24 in. The boiler, of the wagon-bogie type, is 4 ft. 9 in. in diameter, and has 1,930 sq. ft. of heating surface, of which the firebox, 9 ft. in length, affords 233 sq. ft. The total weight of the engine in working order is 55 tons 7 cwt., 37½ tons being available for adhesion. The total weight of engine and tender loaded is 91 tons. No. 999 has made many fine runs, but I need hardly say that the performance of a mile in 32 sec., and at the rate of 112·5 miles an hour, with which it has been credited by imaginative writers, is wholly mythical. It has, however, on many occasions largely exceeded a rate of 80 miles an hour, and that with heavy loads. Indeed, "No. 999" may fairly be said to be one of the finest engines on any railway.—C. R.-M.

Acetylene Generators.

By Professor VIVIAN B. LEWES.

Professor Vivian B. Lewes is widely recognised as being a leading spirit in the gas world. He was educated at University College School, and University College, London, and at the age of sixteen became assistant to the late Professor F. Barff. In 1870 he became assistant to Professor A. W. Williamson, then chief gas examiner of the Metropolis, at the Birkbeck Laboratory. Subsequently Mr. Lewes assumed charge of the same laboratory, and later still he became manager to Professor Williamson at Willesden. In 1879 he joined the staff of the Royal Naval College at Greenwich, and one year afterwards was appointed gas examiner at the Cloth Fair testing station in London. In 1888 he was selected, in succession to Dr. Debus, to the Chair of Chemistry at the Royal Naval College, and subsequently secured the appointment of chief gas examiner of the Corporation of the City of London. As a writer on chemical and engineering subjects Professor Lewes is widely known.

Data recently published by the German Statistical Department show that at the present time, in Germany alone, there are no fewer than 2,750 acetylene generators in use, supplying 170,000 flames, whilst the number of acetylene bicycle lamps employed reaches the respectable total of 25,000; carriage lamps figuring at 15,000, whilst no less than 27 small towns have their streets lighted by this comparatively new illuminant.

These figures speak eloquently as to the wonderful advance made by acetylene, a gas which only came into commercial existence four and a-half years ago, although it had been known and studied by chemists since its discovery in 1836.

At the present moment one is beginning to appreciate the directions in which this beautiful illuminant is most applicable, and a host of acetylene generators claims the attention of those who desire to utilise its wonderful light-giving properties in country houses and institutions where no coal-gas exists, and the would-be purchaser is considerably hampered in attempting to select the form of apparatus best suited to his needs, owing to the number of native generators having been largely added to by recruits from abroad.

It was the discovery that the compound now familiar under the name of calcic carbide could be made directly from lime, and any dense form of carbon, by the action of the intense heat of the electric arc, and the further fact that the body so formed could be decomposed by water with the evolution of a gas having a higher candle power than any other previously commercially made, which led to the introduction of this extraordinary illuminant.

One knows by long practical experience that the universal distribution of a material required to give a specified result is one of the most important factors in its success, and as carbon, carbonate of lime, and water are to be found in some form or other in every part of the inhabited globe

FIG. 1.—EXPERIMENTAL APPARATUS FOR GENERATION OF ACETYLENE.

ACETYLENE STARTS ITS CAREER UNDER AUSPICIOUS CONDITIONS

in this respect. Moreover, the wide spread of the electric light and the continual efforts which have been made to cheapen the production of the electric current, all exercise a beneficent influence in reducing the price of the power needed to weld together carbon with the metal calcium derived from the carbonate of lime to form one of the most remarkable compounds known to chemists.

Once given calcic carbide, the generation from it of acetylene is an operation of the most simple character, as it is merely necessary to bring water in contact with it to set up one of those chemical interactions known as double decomposition, during which the carbon of the carbide uniting with the hydrogen of the water is evolved as acetylene, whilst the calcium attracted by an overwhelming affinity for the oxygen of the water, combines with it to form lime, which slaked by the excess of water present is converted into the compound known as calcic hydrate.

Every operation, however, no matter how simple it appears at first sight, is capable of being performed in several ways, and decomposition of the carbide by water may be brought about either by dropping the carbide into an excess of water or by bringing the water slowly into contact with excess of carbide, and these two main operations may again be varied by innumerable ingenious devices by which the rapidity of the contact may be modified and even eventually stopped. The result of this is, that although the forms of apparatus utilised for this purpose are

ALL BASED ON THE ONE FUNDAMENTAL PRINCIPLE

of bringing about the contact of the carbide with the water which is to enter

FIG. 2.—EXPERIMENTAL APPARATUS EMBODYING THE PRINCIPLE USED IN RECENT GENERATORS.

into double decomposition with it, they have been multiplied in number to a very large extent by the methods employed in order to ensure control in working, and to get away from the dangers and inconveniences which are inseparable from a too rapid generation.

Generators may be divided into two main classes, those in which water is brought in contact with the carbide, the carbide being in excess during the first portion of the operation; and secondly, those in which the carbide is thrown into water, the amount of water present being in excess. The first class may again be subdivided into generators in which the water rises in contact with the carbide, in which it drips on to the carbide, and

FIG. 3.—ADAPTATION OF KIPP'S SULPHURETTED HYDROGEN APPARATUS FOR GENERATION OF ACETYLENE.

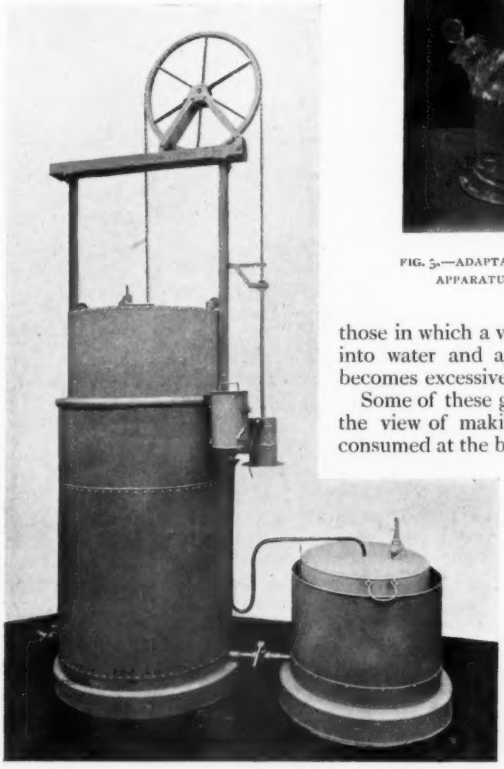


FIG. 4.—MR. GEARING'S AUTOMATIC APPARATUS, PATENTED IN 1894.

those in which a vessel full of carbide is lowered into water and again withdrawn as generation becomes excessive.

Some of these generators are constructed with the view of making the gas only as fast as it is consumed at the burner, with the object of saving the expense and room which would be involved by a storage-holder, and generators with devices for regulating and stopping at will the action going on are generally termed automatic; whilst another set of generators merely aims at developing the gas from the carbide and putting it into a storage-holder with as little loss as possible, and these are termed non-automatic.

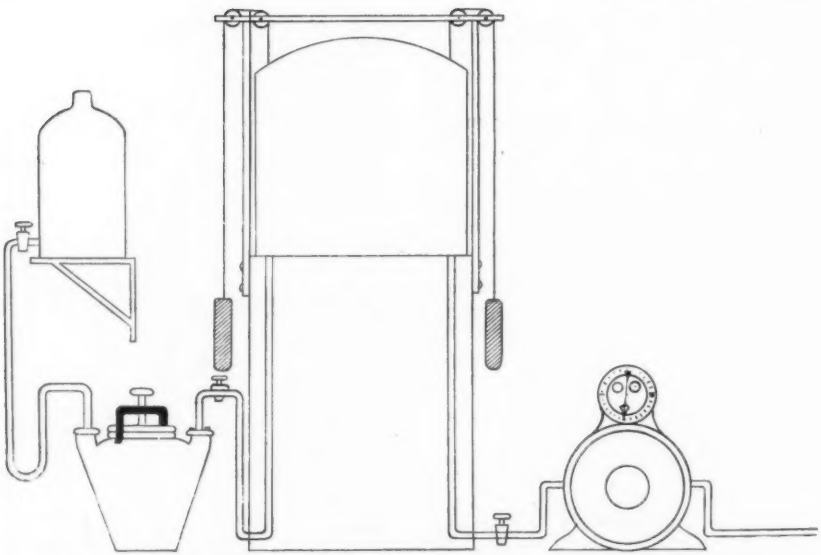


FIG. 5.—AMERICAN APPARATUS ADAPTED FOR THE GENERATION OF ACETYLENE AND SUBSEQUENT ADMIXTURE WITH AIR.

It was in January, 1895, that I first brought

THE SUBJECT OF COMMERCIAL ACETYLENE

before an English audience, and the methods which I then showed for the generation of the gas were of extreme simplicity, and may be taken as being the foster parents of the fine family which has since grown up as more and more attention has been bestowed on the subject.

Carbide was thrown into water, and the gas ignited as it escaped; water was allowed to drip on to carbide contained in a glass flask, and the escaping gas was led into a small gas holder (Fig. 1).

A cage of carbide suspended in a bell-jar placed in a tank of water (Fig. 2) generated the gas, and as the bell-jar rose owing to the contained gas, the carbide was withdrawn from the water and the generation slowed down; whilst a Kipp's sulphuretted hydrogen apparatus (Fig. 3) served to show that a fairly constant current of gas could be maintained by allowing water to rise in contact with the

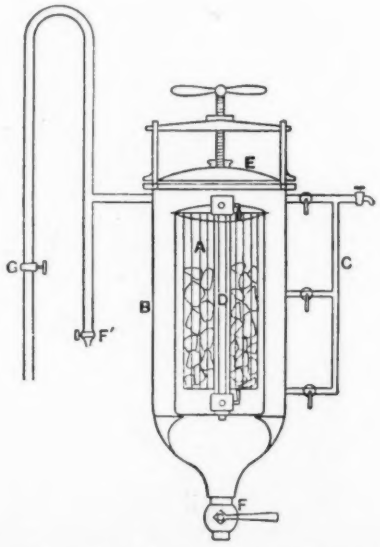


FIG. 6.—SECTIONAL VIEW OF THE "IDEAL" GENERATOR.

carbide—excessive generation by increasing the pressure driving back the water from the carbide.

These laboratory methods soon bore fruit in the crop of generator patents which the next four years brought forth in this country alone. At the end of 1894 there were only two English patents, the first taken out by Mr. T. L. Willson,

THE DISCOVERER OF COMMERCIAL CARBIDE,

and numbered 21,222 of 1894, for a generator in which carbide is decomposed with water which is allowed to drip upon it liberating acetylene, which is stored in a cylinder; and the second taken out by Mr. E. Gearing, and numbered 25,203 of 1894.

Gearing also took out another patent early in 1895 for a generator which consisted of an automatic apparatus (Fig. 4) in which water was allowed to drip upon the carbide contained in a water-sealed generator, the gas being led through a condenser into a holder, the rising bell of which cut off the water when the holder was two-thirds full, whilst as the gas was used and the holder fell, it acted upon a lever that opened a cock and started the flow of water on to the carbide once more.

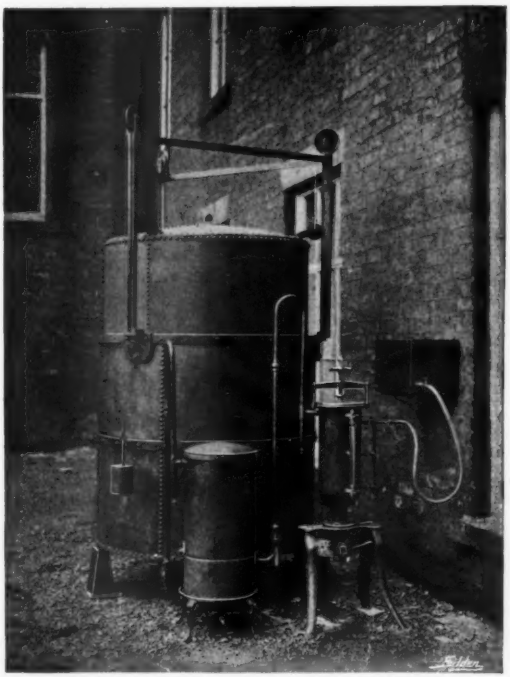


FIG. 7.—THE "IDEAL" GENERATOR.

At this period the idea existed in America—the birthplace of acetylene—that the gas was too rich to be consumed alone, and most of the attempts at burning it had been in admixture with air. The apparatus (Fig. 5) consisted of an earthenware jar fitted with a cover and two necks; into this the carbide was placed, and water was allowed to drip on to it from a pipe through the one neck, whilst the gas was drawn off through the other, and led into a small holder from which it passed into an apparatus in which it was mixed with a certain proportion of air, and then on to the burners.

These early generators were soon followed by a rush on the Patent Office, and Morrison, Dickerson, Ducretet, Camp, Gabe, Kaestner, Atkinson, Bailey, Exley, and Trouvé, filed English specifications — a truly international assortment, as Germany, France, and Sweden contributed to the list.

In 1895 there were 19 generators patented, whilst 1896 added 95 to the list; 1897 showed a still further increase with 111, and 1898 will probably not be far behind when all the applications come to be published—the list at present amounting to 40.

Many of these patents, however, describe forms which have had no existence save

in the inventor's brain, and at the present time there are about

SIXTY FORMS OF GENERATORS ON THE MARKET,

perhaps half that number having what may be termed a commercial existence. Twenty-five of these were exhibited at the Imperial Institute in the summer of 1898, twenty-three obtaining certificates of safety.

Several of the generators resemble each other so closely that a description of each individual one would merely lead to repetition, and the following have been chosen as being typical of the present state of the industry.

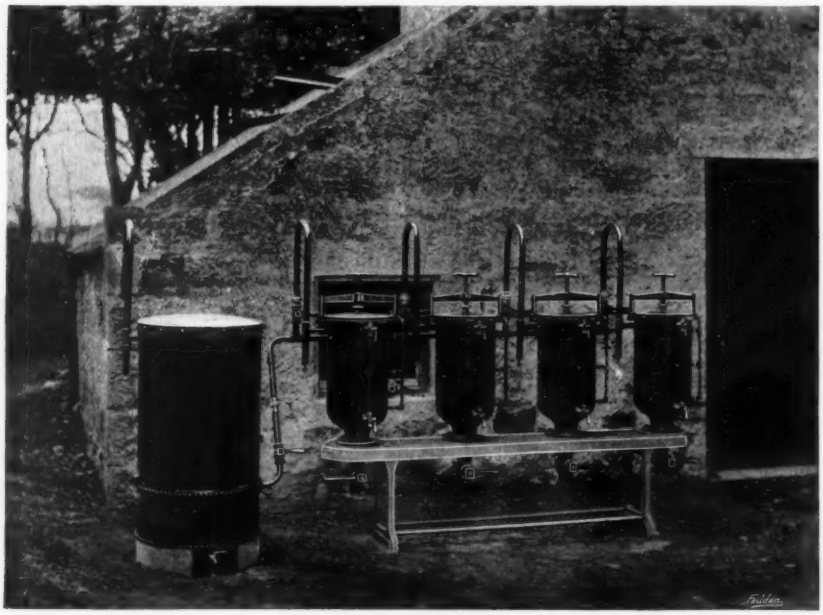


FIG. 8.—BATTERY OF "IDEAL" GENERATORS ARRANGED TO SECURE AN EVEN TEMPERATURE DURING GENERATION OF LARGE QUANTITIES OF GAS.

CLASS I.—Generators in which contact with the carbide is brought about by water rising from below.

THE IDEAL.

This generator (Figs. 6 and 7), which is manufactured in Blackburn, is non-automatic, the main working portion consisting of a generating chamber B, closed by a screw-down lid, and fitted with a gauge-glass D, a sludge cock F, for the removal of the spent lime, and an exit pipe carrying a syphon tube for removing any condensed moisture which may accumulate in the pipe during the making of the gas. This chamber contains the carbide-cage A, and is fitted at the side with tubes by which water can be admitted to the chamber, and as the level of the water rises and reaches the carbide, the gas is evolved.

The whole of the apparatus is so regulated that the liquid only slowly rises in contact with the carbide, and should there be any excess of gas due to over-generation, it stops the inflow of the water into the generator till the pressure again falls, when more enters.

The whole apparatus is extremely

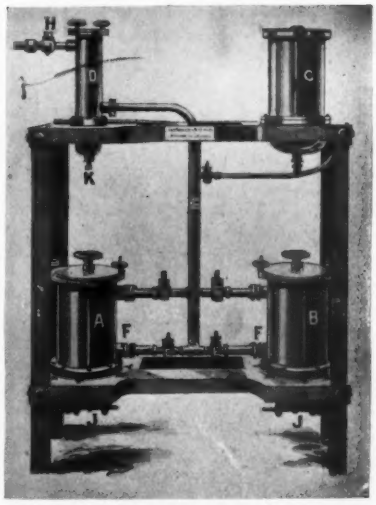


FIG. 9.—"SUNLIGHT" GENERATOR, IN WHICH A MIXTURE OF ACETYLENE AND CARBON DIOXIDE IS PRODUCED.

simple, and works admirably;' the gas, as it is produced, being led into a small holder having a sufficiently large capacity to take the whole of the gas evolved from the largest charge of carbide that the generator can contain, the gas being first passed through a condenser, and, if desired, a purifier, and stored in the holder for use.

I have used this form of generator for a considerable period, and have found it extremely simple and satisfactory in its working.

When the charge is thoroughly spent, the water has risen to the top of the generator. The residues being entirely flooded, there is no danger of any undecomposed carbide being thrown away with the lime sludge, which is

A VERY REAL DANGER IN SOME FORMS OF GENERATOR,

as any carbide left undecomposed will go on generating the gas in the drains into which it may be thrown, and in a confined place might give rise to an explosion.

In order to avoid the evolution of an excessive temperature during generation, it is important that the charge of carbide should be kept small, and in fitting up large installations this is attained by increasing the number of generators instead of increasing them in size, and the accompanying illustration (Fig. 8) shows such a battery arranged to supply gas to a large store gasholder.

Another generator of the same class, also non-automatic, is the "Sunlight" (Fig. 9), in which a novelty is introduced, inasmuch as acetylene mixed with carbon dioxide is produced instead of the pure gas, it having been shown that the diluted acetylene is more easily consumed without risk of smoking at the burner than the pure gas.

In order to do this, the generators A

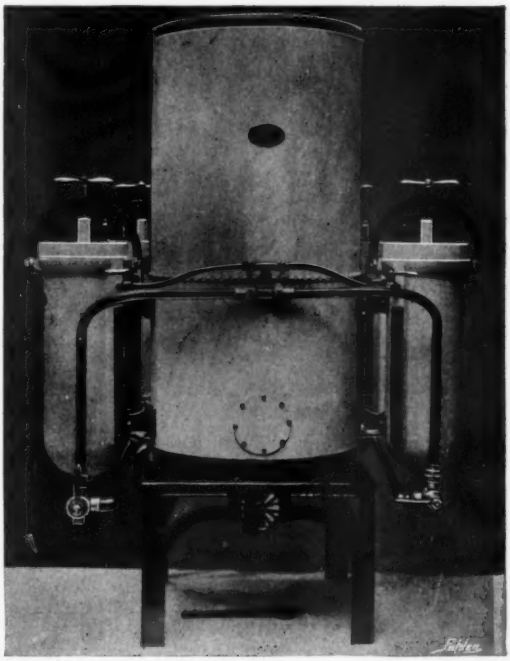


FIG. 10.—MESSRS. EXLEY & CO.'S AUTOMATIC GENERATOR.

and B are made of iron, lined with lead, and contain perforated iron baskets, in which is placed a small proportion of any form of calcic carbonate, whiting being generally employed, whilst on the top of this the charge of carbide is placed. A cylinder, C, also lined with lead, is fixed at a higher level, and contains a 5 per cent. solution of sulphuric acid, which flows down through a pipe and enters the generating cylinders at a point, F, close to their base. As it rises, the dilute acid comes in contact with the calcic carbonate, evolving carbon dioxide, whilst, on reaching the carbide, acetylene is also produced. The mixed gases leaving the generator then pass through the exits at G, and travel upwards to a cylinder, D, which contains the purifying material employed, consisting of a copper salt which removes the sulphuretted and phosphuretted hydrogen, the purified gas then going forward to the gas holder.

It has been proved that the small amount of carbon dioxide has but little effect on the illuminating power, and has a distinct action in doing away with the danger of smoking.

A POPULAR FORM OF AUTOMATIC GENERATOR

(Fig. 10) is made by Exley & Co., of Huddersfield, in which the generating chambers consist of vertical retorts placed around a cylindrical iron vessel, the lower portion of which is a water-tank and gas-holder, whilst the upper portion contains a condensing coil and also acts as an overflow when the water is driven back from the lower tank by excessive generation of gas. The generators, which vary in number according to the capacity of the plant, contain cages, into which the carbide is

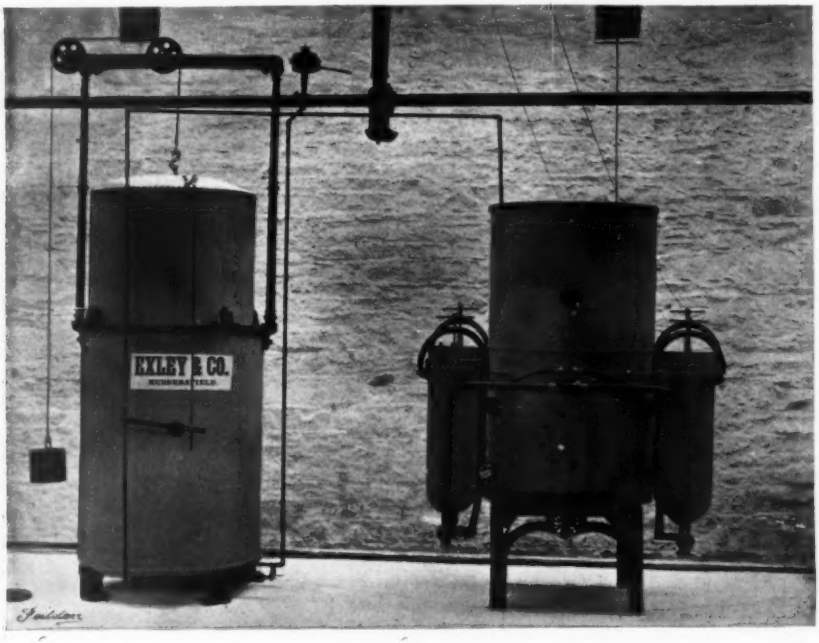


FIG. 11.
MESSRS. EXLEY & CO.'S TYPE OF GENERATOR, WITH SEPARATE GASHOLDER.

placed, a screw-down cover making the whole gas-tight. Water is admitted from the central tank to the bottom of the generator, and rises until it reaches the carbide. The gas which is then evolved is led from the generator into the upper portion of the water-tank, and collecting there, drives the excess of water into the upper tank, and as soon as the pressure reaches a certain point, the pressure of gas drives back the water from the carbide. The water again falling from the overflow tank as the gas is consumed, rises to the carbide once more, so that the supply of water to the carbide is automatically regulated by the pressure of gas within the gas-holder. As soon as the decomposition is complete in one generator, and the water has risen to the top, it flows over into the second generator, and this action continues until the whole battery has been exhausted.

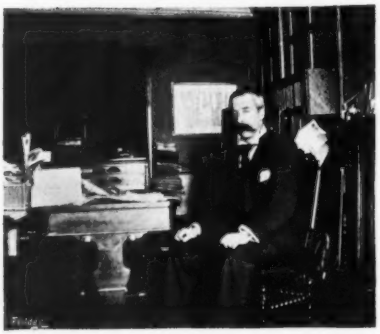
In some cases where it is imperative to have a gas-holder, the apparatus (Fig. 11) is connected directly with it, and the gas being then made steadily until the holder is full, variations in pressure are done away with.

(*To be continued.*)

William B Lewes

The Iron Making Blast Furnace as an Ideal Power Producer . . .

By HORACE ALLEN, C.E.



MR. HORACE ALLEN was born in Hackney, September 5th, 1858. Entering the works of the Barrow Hæmatite Steel Co., Ltd., he spent a couple of years in the pattern shop, then seven years in the Engineering drawing office, following this by ten years in the laboratory. From being assistant chemist he was put in full charge of the then extensive laboratory in 1889. No better opportunity of becoming proficient in the metallurgy of iron and steel could be obtained than that afforded by the seventeen years in the drawing office and laboratory. In 1890 he left the Barrow Hæmatite Steel Co. to undertake the duties of assistant manager to construct and work a large Siemens' steel works near Bilbao, but returned to England the following year on the scheme being abandoned. He later held the position of assistant engineer at the works of the Tubular Frame Wagon Co., designing and constructing rolling stock of high carrying capacity compared with the tare; as well as having had charge of the patent steel cask department at the Bowling Iron Co.'s Works, the casks being made of sheet steel rolled by a patent process and electrically welded. As a lecturer on the manufacture of iron and steel, in connection with the City and Guilds of London Institute, he was very successful, and he has also contributed papers to the Institute of Civil Engineers, of which he was an Associate Member. Mr. Allen has been associated with B. H. Thwaite, Esq., in research work relating to thermo-dynamic and metallurgical subjects.

A NEW REVOLUTIONISING INVENTION.

PROBABLY, since the introduction of hot blast by Neilson and Condie in 1828, no greater advance has been conceived during this century, in the economy of blast furnace practice, than that of the utilisation of the so-called waste gases issuing from blast furnaces for the direct production, in the cylinders of internal combustion engines, of motive power—thus securing the highest efficiency in the conversion of heat into motion. The original inventor of the system is a Britisher, Mr. B. H. Thwaite.

A GREAT ECONOMY.

While under boilers it requires the combustion of from 600 to 700 cubic feet of the effluent blast furnace gas to develop, in steam engine cylinders, the power of one indicated horse for a period of one hour, the same volume of gas when employed in the cylinders of an internal combustion or gas engine of suitable design will develop from 5 to 7 indicated horse power—thus securing in one operation an increase of over 500 per cent. in efficiency, and without requiring the dangerous steam boiler. Though the heating of the air blast resulted in such a large saving in the weight of fuel necessary to produce one ton of pig iron, the application of the evolved gases to the development of power in gas engines, by the patented system of B. H. Thwaite and Frank L. Gardner, producing, as it

does, one indicated horse power for every 1·3 to 2·0 lbs. of fuel charged into the furnace for smelting the iron, makes it a question for serious consideration whether, in certain circumstances, it would not be more profitable to merely warm the air blast by the sensible heat of the effluent gases and utilise all the gases evolved from the furnace for the production of power. In all circumstances, however, it is profitable to secure the highest efficiency in the conversion of the heat of the effluent gases into power.

SCOTLAND'S HONOUR.

It is curious in this connection to note that to Scotland belongs the honour of practically initiating both the Neilson and the Thwaite innovations. It was in a Scotch Works where the heating of the blast was first introduced in 1828, and also a Scotch firm who have the honour of having put down the pioneer plant of the Thwaite-Gardner Patented System in 1894-5.

THE BLAST FURNACE.

The blast furnace requires for its continuous economical working, as in the practice of the present time, air blast, heated to from 1,200° F. to 1,400° F., and supplied under a pressure of from 5 to 10 lbs. per square inch above the atmosphere.

DR. VON OTTO, INVENTOR OF THE CELEBRATED GAS ENGINE, WHICH BEARS HIS NAME.

MR. B. H. THWAITE, THE ORIGINAL INVENTOR OF THE THWAITE-GARDNER BLAST FURNACE SYSTEM.

The volume of the blast is proportional to the desired output of the furnace, being necessary for the combustion of the fuel to the extent of providing the required reducing environment for the iron ore, and heat for melting the reduced metal and slag, including the chemical reactions which take place in the smelting of pig iron of the required quality.

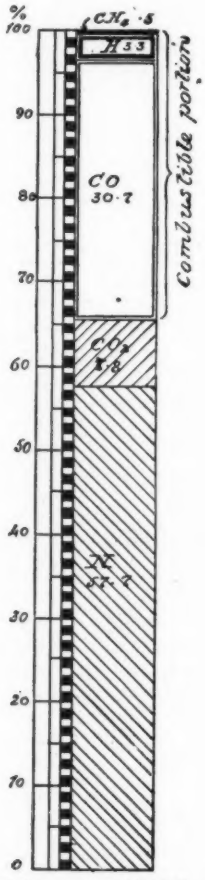
This partial combustion of the carbonaceous portion of the fuel results in the evolution of large quantities of gas from the top of the furnace.

THE GAS, ITS COMPOSITION.

The composition of the evolved blast furnace gas, chemically considered, varies somewhat in its composition in different furnaces, but as air blast is the source of oxidation used for the combustion of the fuel in the blast furnace, there is always a very considerable proportion of nitrogen present. Carbonic acid gas is another constituent, to a greater or less extent, and the proportions of the two gaseous and inert elements are dependent in a considerable measure upon the character of fuel used. Nitrogen and carbonic acid are both incombustible gases, but along with them is also a large proportion of carbonic-oxide gas, with also small quantities of hydrogen and marsh gas. These latter gases, e.g. carbonic oxide, hydrogen, and marsh gas, form the combustible

which is available for the development of power, by their direct combustion in the cylinder of an internal combustion engine, the modern development of which we owe to Dr. Von Otto.

Where coke is the fuel employed, there

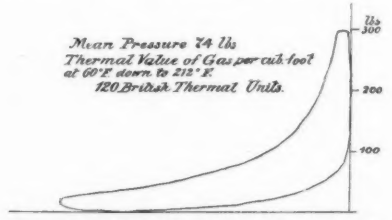


BLAST FURNACE GAS. GRAPHIC DIAGRAM. PERCENTAGE COMPOSITION BY VOLUME.

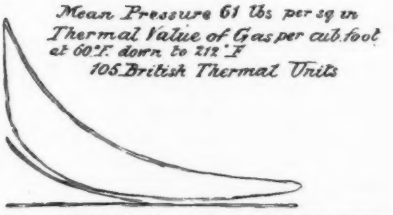
are given off from 170,000 to 180,000 cubic feet of gases for each ton of coke consumed, if measured at 60° F.

If raw coal is employed as fuel, the quantity of gases given off per ton of fuel falls to about 130,000 cubic feet, measured at 60° F., but the proportion of combustible gas is higher, and each ton of pig iron produced requires a larger proportion of fuel than when coke is used, the fixed carbon content of the fuel being the controlling factor.

The examination of a number of analyses of the gases escaping from furnaces using different classes of ore and fuel, shows that the proportion of combustible gas, carbonic oxide and hydrogen,



THE THWAITE-GARDNER BLAST FURNACE POWER SYSTEM. COPY OF DIAGRAM FROM A GAS ENGINE OF 150 I.H.P. USING BLAST FURNACE GAS FROM COKE-FED FURNACES.



THE THWAITE-GARDNER BLAST FURNACE POWER SYSTEM. COPY OF DIAGRAM FROM A GAS ENGINE OF 250 I.H.P. USING BLAST FURNACE GAS FROM COKE-FED FURNACES.

is not dependent always upon the weight of fuel required to produce one ton of pig iron, some furnaces using about 28 cwt. of coke per ton of pig iron giving gases poorer in combustible than others employing only 19 cwt. of coke.

With a certain class of ore, flux and fuel, it is found that the composition of the waste gases is very constant under all circumstances of the working of the furnace.

The poorest gases are produced from coke-fed furnaces, and the percentage of carbonic oxide by volume is from 25 to 35 per cent., while the percentage of hydrogen is generally about 2 per cent.;

also, where it has been determined, there is found to be about 0·5 to 2 per cent. of marsh gas present. There is also in mechanical association a certain proportion of aqueous vapour.

From the comparison of various analyses of the waste gases, it is a very simple calculation to ascertain the thermal value per cubic foot.

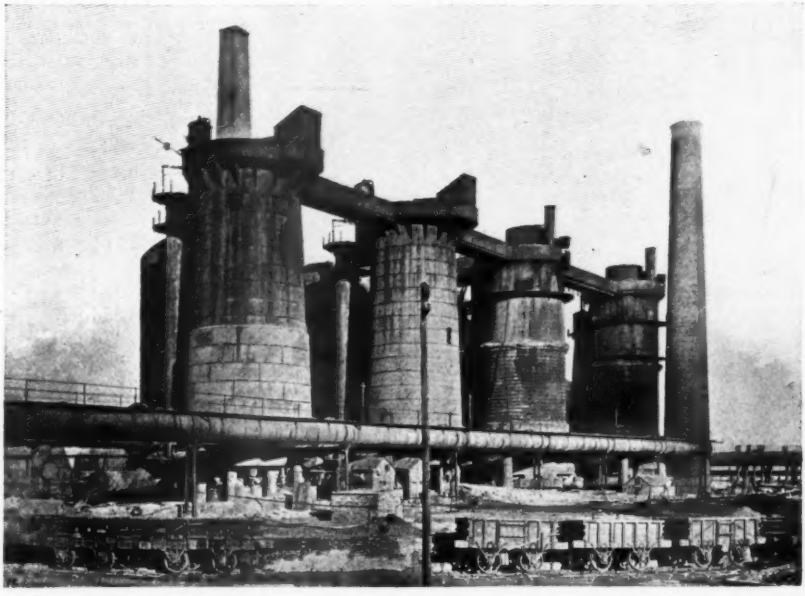
The following factors are all that are necessary:—Thermal value of the different combustible gases per cubic foot, measured at 60° F., when the products of combustion are considered as not lower than 212° F.

Carbonic oxide,	CO,	per cub. ft.,	319	British thermal units
Hydrogen,	H,	,, ,,	282	,,
Marsh gas,	CH_4,	,, ,,	908	,,

Blast furnace gas of 120 British thermal units, when employed to drive gas engines, will give from 60 to 70 lbs. per square inch mean pressure in the cylinder, and to develop 1 indicated horse power requires the consumption of less than 100 cubic feet of gas per hour, while from all available determinations it is necessary to supply from 600 to 700 cubic feet to produce the same power in a steam engine by combustion under dangerous steam boilers.

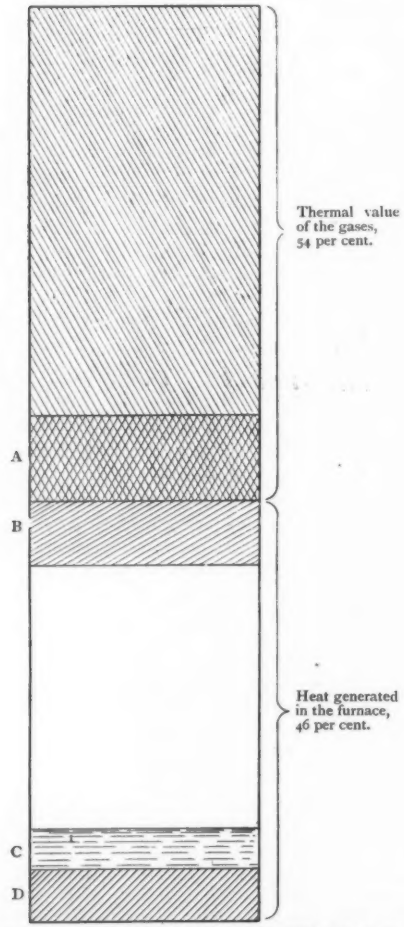
HEATING THE AIR BLAST, AND PROVIDING IT UNDER PRESSURE.

Where blast furnaces are not associated with any other manufacture requiring steam power, it has generally been considered the acme of economy to utilise the gases escaping from the furnaces (1) to heat the blast, by combustion in hot blast stoves, (2) to generate by steam boilers the power required to provide the blast, pumping and hoisting machinery. The introduction of the internal combustion engine quite revolutionizes this arrangement, and provides from four to five times the horse power of the blast and



BLAST FURNACES AT WISHAW, HÆMATITE ORE, BITUMINOUS COAL FUEL. PIONEER INSTALLATION OF THE THWAITE-GARDNER BLAST FURNACE POWER SYSTEM.

hoisting engines, as a source of profit, by using it for providing power for electric distribution, without taking into account the power that would be available by the fullest application of the Thwaite-Gardner patents, one of which provides a cover for the charging bell and hopper, thus saving the gas which under present arrangements is allowed to pass into the atmosphere.



BLAST FURNACE HEAT DIAGRAM IN PERCENTAGE OF THE THERMAL VALUE OF THE FUEL.

A. Heat used in heating the blast, 9·3 per cent.
B. Carried out of furnace as sensible heat by the gases, 7·0 per cent.
C. Heat carried out by the slag, 4·4 per cent., sensible and latent.
D. Heat carried out by the molten iron, 5·7 per cent., sensible and latent.

STATISTICAL EVIDENCE.

Taking, for instance, a blast furnace producing 600 tons of pig iron per week, with a consumption of 1 ton of coke per ton of pig iron:

The consumption of coke per hour would be 3,571 tons.

The volume of gases, measured at 60° F., evolved per hour would be about 607,070 cubic feet.

Allowing one-third this quantity for heating the blast by combustion in fire-brick hot-blast stoves, leaves 394,714 cub. ft. for power purposes, but with the present charging arrangements and their associated element of waste, not less than 10 per cent. of the total volume of gas is allowed to pass away into the atmosphere. We must therefore deduct this quantity from that which should otherwise be available:

10% of 607,070 = 60,707 cubic feet.

394,714 − 60,707 = 334,007 cubic feet of gas available for power purposes.

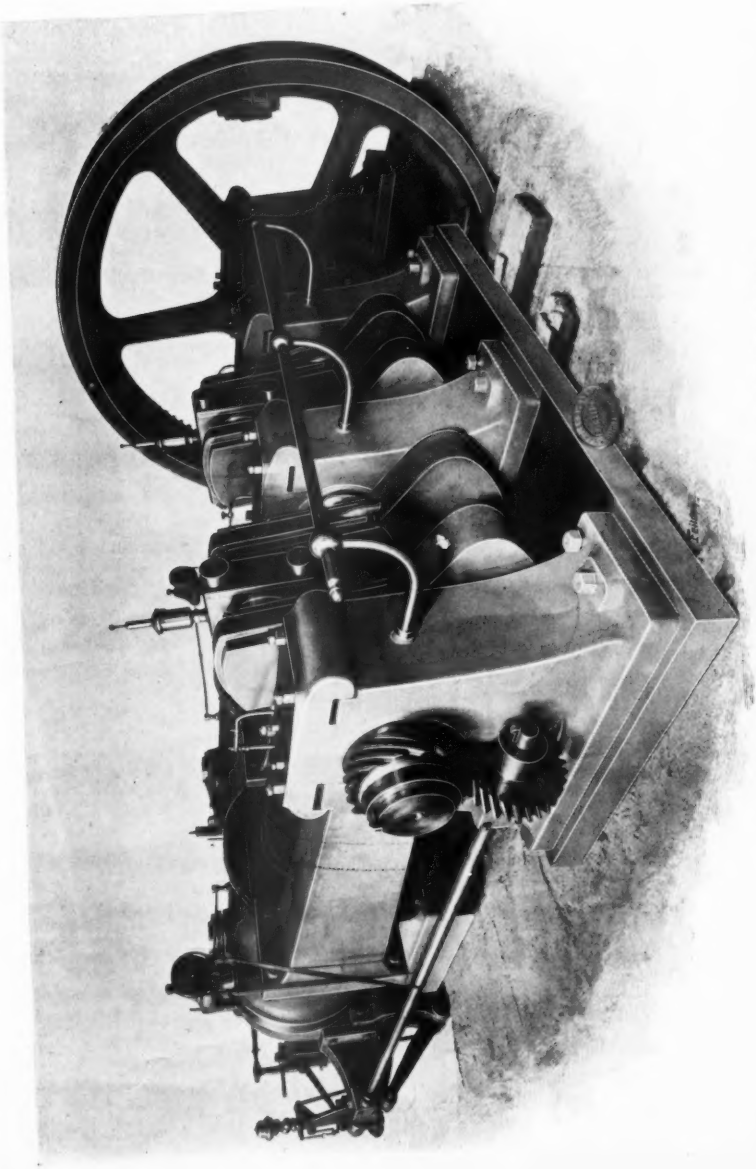
Assuming the gases to have a thermal value of only 95 British thermal units, and that the gas engine requires 140 cubic feet per indicated horse power per hour, we have a gas supply equal to 2,386 indicated horse power.

THE ALLOCATION OF POWER.

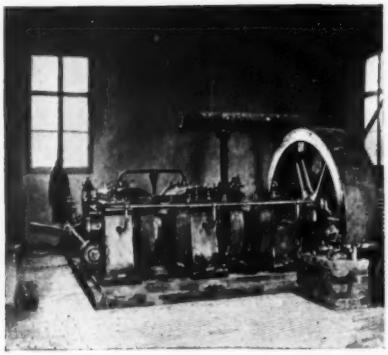
For supplying the blast there would be required about 275 I.H.P., hoisting and other purposes might absorb 30 I.H.P., leaving as power available for electric distribution or other purposes 2,081 I.H.P.

If, however, the conditions of working of the furnace gave gases having a thermal value per cubic foot of 120 B.T.U., and this is not uncommon even with coke-fed furnaces, the consumption of gas in the gas engine would only amount to 100 cubic feet per I.H.P., in which case the gases would be capable of developing 3,340 I.H.P., and allowing as above 305 I.H.P. for blowing engines, and hoisting, &c., there would be available a continuous power of 3,035 I.H.P.

It will however be noticed that a loss of



TYPE OF GAS ENGINE, 150 TO 250 I.H.P., USED WITH THE BLAST FURNACE POWER SYSTEM.

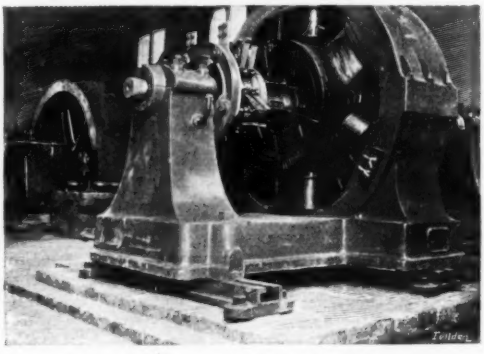


GAS ENGINE DRIVEN BY BLAST FURNACE GAS. THWAITE-GARDNER PATENTS. 150 H.P. PLANT. GERMAN INSTALLATION.

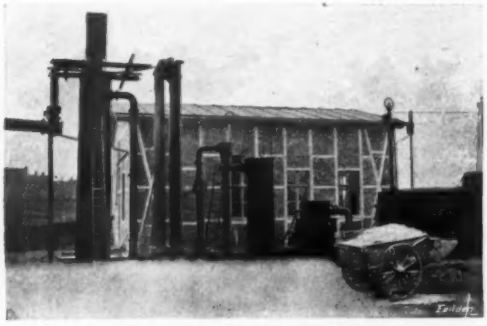
10% has been allowed, and this loss can be greatly reduced. The loss of 60,707 cubic feet of gas allowed to escape into the atmosphere is equivalent to the loss of 607 I.H.P., or a total of 3,642 I.H.P. should, without affecting the quality or production of pig iron, be at the disposal of the iron masters as a saleable commodity. Calculated upon one ton of pig iron production per week there should be available 6 indicated horse power for profitable disposal. From the foregoing it will be seen that for each (1) 1·84 lbs. (2) 1·32 lbs. of coke charged into the blast furnace for smelting the pig iron, under ordinary working conditions, one indicated horse power per hour is developed. This is such an economical result that where the outlet for the power tends to exceed the surplus of gas evolved, a slight increase in the proportion of fuel to ore would not have the effect of increasing the cost of the iron because the extra power would pay for the extra fuel, and blast furnace managers would be relieved from the anxiety of doing all in their power to keep the fuel consumption per ton of pig down to its lowest point.

THE OBLITERATION OF THE STEAM BOILER ELEMENT.

Were the Thwaite-Gardner patents to be adopted to their fullest extent in new plants, no dangerous and wasteful steam boilers would be required, and in this connection, when it is considered that the gas engine is much more simple and compact than a steam engine, the cutting out entirely of boilers, with all their anxieties and dangers, water, fuel supply, &c., will be fully appreciated by every ironmaster, furnace manager and mechanical engineer. Where the application of the gas engine to the blast furnace plant is of only a partial



ALTERNATING LAHMEYER DYNAMO, USED FOR CALCIC CARBIDE PRODUCTION WITH BLAST FURNACE GAS. (SHEWING GAS ENGINE.)



A WESTPHALIAN POWER GENERATING STATION. THWAITE-GARDNER PATENTS.

character, and one or more boilers are retained for stand-by purposes, the circulating water necessary for keeping the gas engine cylinder cool will be available for feeding the boilers, and the heat carried out of the gas engine cylinder, amounting to between 20 and 40% of the heat originally contained in the *coke*, can be converted into power by the boiler, therefore adding to the economy of the plant.

For starting the plant, and as a permanent auxiliary, there is provided a Thwaite power gas generator plant, of sufficient capacity to permit the rapid evolution of such an amount of power as to provide for any emergencies. The generators may be employed for heating hot blast stoves or the gases may be used along with that from the furnaces supplying the system, a poor quality of fuel being utilised for this purpose, and of course the generator plant need only be urged as required.

NO NECESSITY TO BLOW OUT THE BLAST FURNACE.

The Thwaite power gas generators differ from other ordinary sources of power in the rapidity with which they can be started up, say one and a-half to two hours from cold.

When the iron market is overstocked, the blast furnaces need not be blown out (an operation of great cost and always involving a rapid deterioration of the furnace), but the furnace may be profitably maintained in operation for the purpose of producing power.

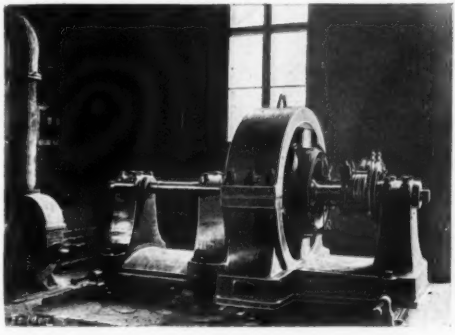
It has not been realised how ideal a fuel blast furnace gas really is, and for all purposes requiring the continuous and regular production of power.

Seeing that the class of iron ore, the fluxing material and weight of coal or coke are all constant quantities, the thermal value of the gases must also be constant, and as the process of pig iron manufacture is practically continuous, the supply and volume of the gaseous fuel is constant and not dependent upon the ability and regularity of the stoker, as in the case of steam boilers and gas producers.

THE UTILISATION OF THE POWER.

Having demonstrated that such large sources of power are at the hands of blast furnace proprietors, it will be a favourable opportunity to indicate how this power may be most profitably employed.

(1) In the first place, the most profitable and economic use of the internal combustion or gas engine is the actuation of air-blowing cylinders; the pressure at which the air blast has to be delivered to the furnace being comparatively low, 5 lbs. to 10 lbs., there will be no disadvantage in running the blowing pistons at the speed usually adopted in gas engine practice, so that the blowing pistons can be driven by connecting rods and cranks on the shaft of the gas engine. The Thwaite-Gardner series rotating blowers are, however, available for developing large volumes of air blast. Their use does not restrict the piston speed of the gas engine. Besides this, reciprocating piston arrangements have been devised permitting modern blowing engines to be driven by the new power system.



ALTERNATING LAHMEYER DYNAMO, USED FOR CALCIC CARBIDE PRODUCTION WITH BLAST FURNACE GAS (SHOWING COMPOUND FAN) THWAITE-GARDNER PATENTS.

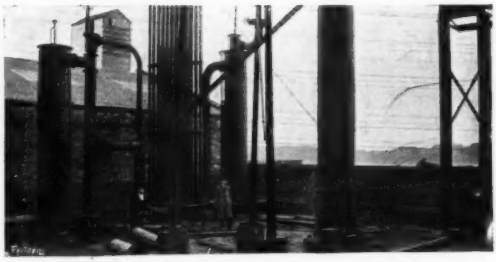
(2) As the cleansed and filtered gas can readily and conveniently be taken to any reasonable distance, *without entailing any loss due to condensation as in the example of steam*, any continuous running steam engine can with advantage be displaced by one of an internal combustion or gas engine type. For instance,

the engine for pumps for tuyere water and other purposes can be run continuously by gas engines, either direct or by gearing, belts, or ropes. The usual fitting and repairing shop machinery can with advantage be also driven by a gas engine.

THE ELECTRIC ASSOCIATE OF THE NEW POWER SYSTEM.

(3) All the small machinery required in engineering shops, steel works, etc., such as lathes, saws, cranes, straightening presses, capstans, line rollers, and so on, could most economically and profitably be actuated by preferably polyphase electric motors, which should receive the necessary current from a central generating station in which the dynamos are driven by the Thwaite-Gardner system of using gas engines driven by blast furnace gas.

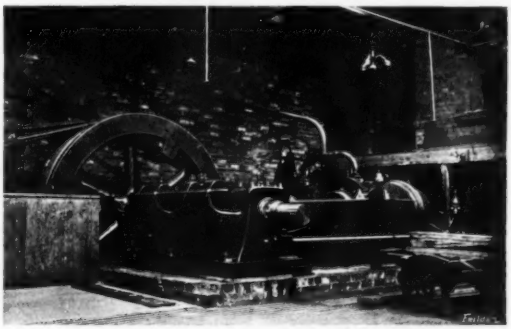
(4) When the generating station is installed, there is, of course, a large outlet for the excess of power over that required on the works in connection with the blast furnace.



VIEW SHOWING PORTION OF BLAST FURNACE POWER GAS TREATMENT PLANT OF A LARGE ENGLISH IRONWORKS.

BLAST FURNACE POWER SYSTEM, THWAITE-GARDNER PATENTS. VIEW OF PRESSURE GOVERNOR HOLDER FOR BLAST FURNACE GAS AT ENGLISH COKE-FED FURNACES.

Electric lighting takes probably the first place for a limited portion of the power, after which, as electric power can be so economically and efficiently transmitted to considerable distances, the available power can by dynamos and motors be made to work electric railways or tramways, canal haulage plants, electric welding, electric fusion, etc., etc. The equalising of the power output, as well as the allowance for the variations in the demand, with the object of keeping the gas engines running as nearly as possible for the full 24 hours per day, at a constant speed and power, can be easily effected by the installation of auxiliary plants that permit the plant to be kept in practically ceaseless operation.



BLAST FURNACE POWER SYSTEM, THWAITE-GARDNER PATENTS. 250 I.H.P. GAS ENGINE, DRIVEN BY BLAST FURNACE GAS FROM ENGLISH COKE-FED FURNACES.

AN EXAMPLE OF THE APPLICATION OF THE NEW POWER SYSTEM.

In the Westphalian Iron District in Germany, a Thwaite-Gardner plant has been put down for the utilisation of blast furnace gas for producing the electric energy necessary for the manufacture of calcium carbide.

The gas is taken from the main tubing from the blast furnaces, and treated by the Thwaite-Gardner patented process of purification, condensation and filtration, and then used for actuating a gas engine of 150 I.H.P.

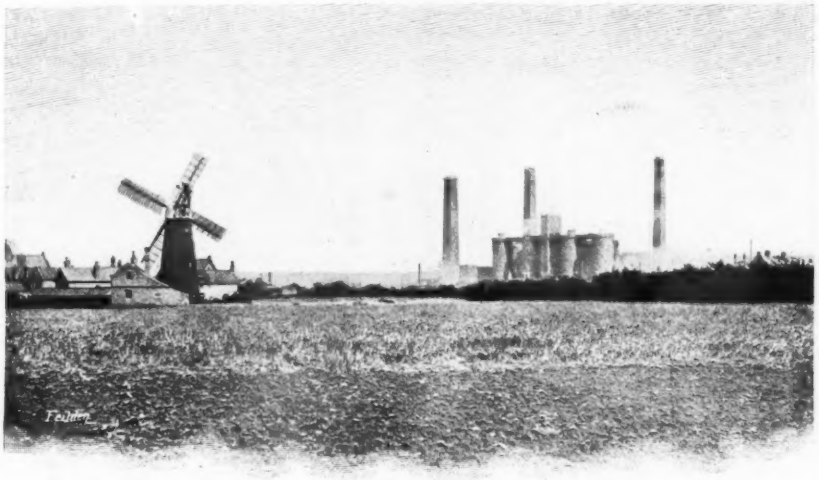
Arrangements are provided to regulate the pressure of gas to the engine.

From the fly-wheel, a belt communicates the power to a dynamo, which provides the electric current for the calcic carbide furnaces.

The following is a fairly characteristic composition of the blast furnace gas averages, in percentage proportions, by volume :—

Carbonic acid, CO_2 . .	7·8
Carbonic oxide, CO . .	30·7
Hydrogen, H . . .	3·3
Marsh gas, CH_4 . . .	·5
Nitrogen, N . . .	57·7
	100·0

The thermal value of the gas at



THIS PHOTOGRAPH IS UNIQUE IN THAT IT REPRESENTS THE STEP-UP FROM THE OLD POWER TO THE NEW. THE WINDMILL IS STILL A COMMON FEATURE IN MANY EASTERN LANDSCAPES. THE FURNACES ARE THOSE FROM WHICH GAS WAS FIRST UTILISED BY THE THWAITE-GARDNER SYSTEM IN ENGLAND.

For starting the main engine, barring gear is employed, actuated in this case by a small gas engine.

The supply of gas is kept constant, the supply being effected by means of a combined compound centrifugal exhauster and blower situated in the series of the treatment plant, which works absolutely automatically. When once the engine is started, its operation is continuous, all auxiliary apparatus being driven from it.

60° F. down to 212° F. = 111·7 British thermal units.

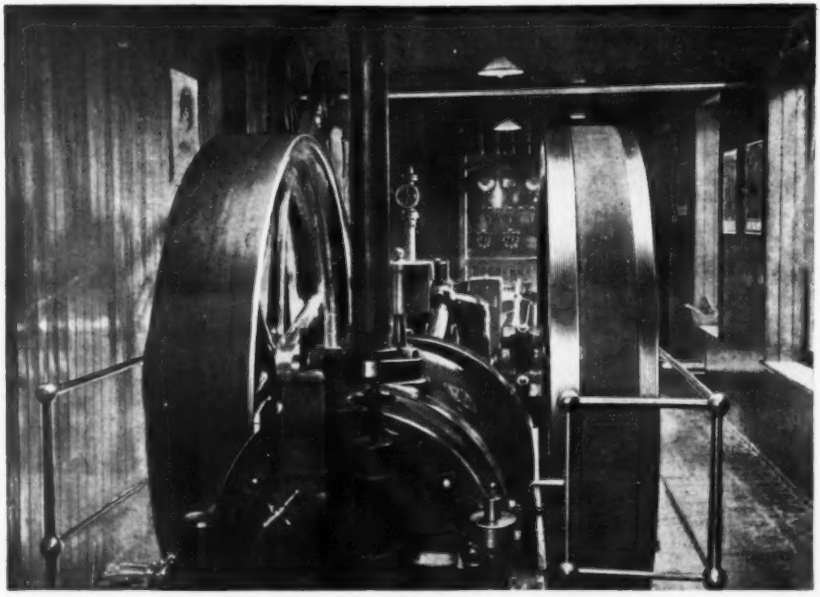
The mean pressure developed by the explosion of this gas in the cylinders of the gas engine, as shown by the indicator, equals 60 to 70 lbs. per sq. in. The gas engine has duplex cylinders, and there is therefore one explosion for each revolution. In engines of 1,000 I.H.P., four cylinders are so provided as to distribute the effect of the energy as equally as

possible around the throw of the crank, the balancing being practically perfect.

In Germany, the power developed by the new Thwaite-Gardner power system is being utilised for the production of calcic carbide; in England for electric light and power; and in Scotland, for electric lighting. The large plant in course of erection in France is intended for the supply of energy for electric traction and for lighting purposes. The new power system opens up a new era of usefulness for the small but well-distributed blast furnaces, whose existence were once evidence of industrial strength, but whose extinction is threatened by the larger furnaces. The smaller furnaces being generally situated in the centre of manufacturing areas, the power developed can be disposed of to the best advantage. The new system promises, therefore, to restore the Midland and other iron-making districts to their former condition of great prosperity, because cheap power more than ever is essential to industrial prosperity. In the new system this condition is secured, and without being associated with danger in the production of air-polluting smoke.

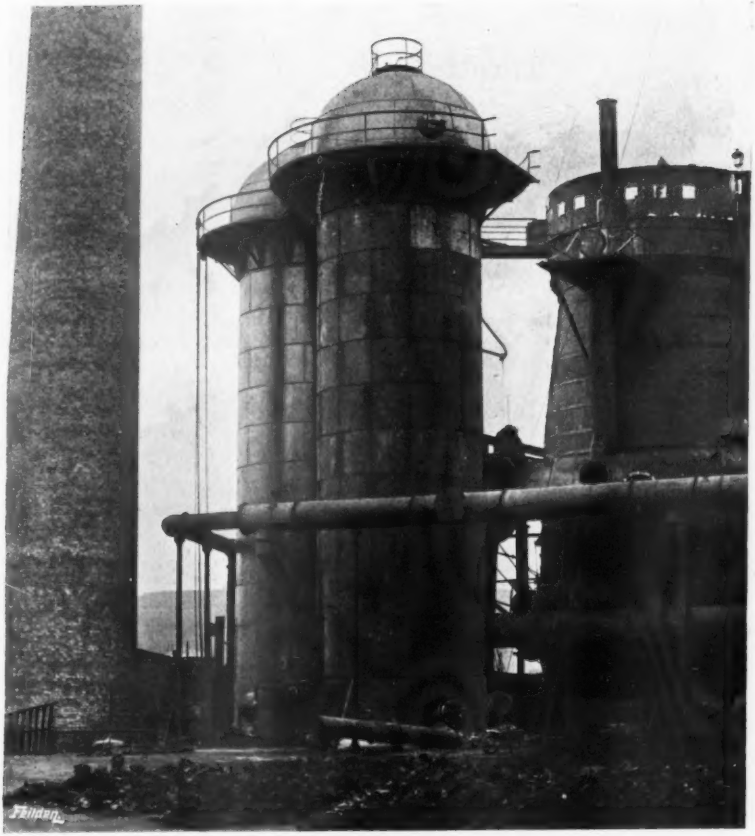
The Automatic Signalling Gas Pressure Gauge, used in conjunction with the power plant, and forming one of the group of Thwaite-Gardner patents, automatically draws attention to any important change in the pressure of the gas in the blast furnace gas mains, by ringing an electric bell, either when the pressure is low or when it is higher than the normal degree. The contact points can be adjusted to record any desired pressure, or any range of pressure, and the electric bell can be placed in any convenient position.

Any occurrence associated with the working of the furnace is thus immediately notified in the engine-house, even the times and duration of charging and tapping.

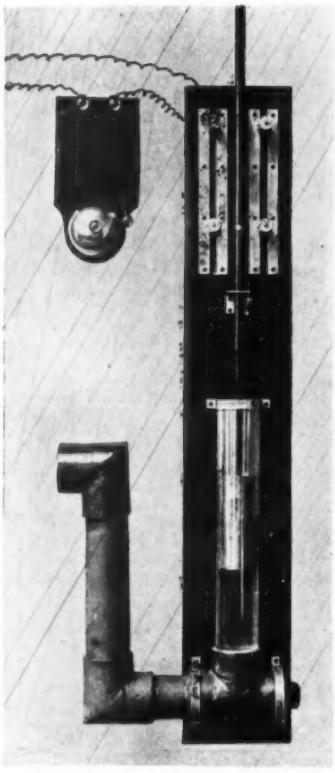


INTERIOR VIEW OF A THWAITE-GARDNER BLAST FURNACE POWER INSTALLATION, SHOWING ELECTRIC POWER MACHINERY.

Horace Allen



BLAST FURNACE POWER SYSTEM, THWAITE-GARDNER PATENTS. PHOTOGRAPH OF A FRENCH BLAST-FURNACE, THE FIRST TO APPLY THE SYSTEM IN FRANCE.



AUTOMATIC SIGNALLING GAS PRESSURE GAUGE, THWAITE-GARDNER PATENTS.

BIBLIOGRAPHY TO DATE.

Leading Article, *Iron and Coal Trades Review*, November 16th, 1894.

"Le Moteur à Gaz," par M. RICHARDS. (1895 Edition.)

"Note on the Application of Blast Furnace Gases to Gas Engines." Professor W. H. WATKINSON, M.I.M.E. *Journal of the West of Scotland Iron and Steel Institute*, March 15th, 1895.

"*Electrical Review*," April, 1895.

"*Le Rappel*," Paris, September 24th, 1895.

"The Economics of Electrical Transmission of Power." WALTER DIXON, F.R.M.S., Electrician. *Journal of the West of Scotland Iron and Steel Institute*, December 18th, 1896.

"A New Industry for Ironmasters: The Production and Distribution of Power developed by the Thwaite-Gardner Blast Furnace Power System," Vol. I., 1897. Prospectus published by the Blast Furnace Power Syndicate.

"Appendices to Prospectus of the Blast Furnace Power System; A Series of Pioneer Inventions, Thwaite-Gardner Patents," 1897.

"Pig Iron as a Possible Secondary Product of the Blast Furnace." B. H. THWAITE, Assoc.M. Inst.C.E. *Iron and Coal Trades Review*, January 29th, 1897.

"The Utilisation of Blast Furnace Gases by means of the Gas Engine." WILLIAM GALBRAITH, M. Iron and Steel Institute. *Journal of the West of Scotland Iron and Steel Institute*, November, 1897.

"L'Utilisation des Gaz des Hauts-Fourneaux." M. ARTH, Professor à la Faculté des Sciences de Nancy, Société Industrielle de L'Est Conference. December, 1897.

"L'Energie par les Hauts-Fourneaux; Utilisation rationnelle du Gaz, Système Thwaite-Gardner." Published at Saint-Dizier, France, 1898.

"L'Utilisation des Gaz des Hauts-Fourneaux," *vide* "L'Ancre," de Saint-Dizier. *Journal de la Metallurgie*, January 25th, 1898.

"The Utilisation of Blast Furnace Gases for Electrical Power Transmission." W. H. BOOTH, M.Am.Soc.C.E. *Electrical Review*, April 22nd and May 6th, 1898.

"On the Use of Blast Furnace Gas for Motive Power." ADOLPHE GREINER. With important discussion by Mr. James Riley, Vice-President Iron and Steel Institute, and Mr. Snelus, F.R.S., etc. *Journal of the Iron and Steel Institute*, May, 1898.

"On Commercial Methods of Utilising Blast Furnace Gases for Power Production, and their possible effects on the Pig Iron Industry." B. H. THWAITE, Assoc.M.Inst.C.E. *Iron and Coal Trades Review*, May 6th, 1898. Paper read before the British Iron Trade Association, in May, 1898.

"Utilisation of Blast Furnace Gases for the Production of Power." W. H. BOOTH, M.Am. Soc.C.E. "*Engineering Magazine*," New York, June, 1898.

"The Economical Use of Blast Furnace Gas." *The Practical Engineer*, June 10th, 1898.

"Utilisation directe des Gaz de Hauts-Fourneaux dans les Moteurs." *Revue Industrielle*, Paris, June 11th, 1898.

"Utilisation des Gaz de Haut-Fourneaux dans les Moteurs à explosion." *Le Génie Civil—Revue Générale hebdomadaire des Industries Françaises et Etrangères*. M. AUG. DUTREUX. July 23rd and 30th, 1898.

"*Railway World*," September 8th, 1898.

"The Blast Furnace as a Source of Power." *Journal of the South Staffordshire Institute of Iron and Steel Works Managers*, December, 1898.

"The Blast Furnace as a Power Producer." Data relating to this and allied subjects. B. H. THWAITE, C.E., F.C.S., HORACE ALLEN, C.E. 1898.

H. A.

An Electrolytic Process

For the Manufacture of Parabolic Reflectors for Searchlights and Locomotive Headlights.

By SHERARD COWPER-COLES, M.I.Mech.E., A.M.I.C.E., Etc.

MR. SHERARD COWPER-COLES was born in the Isle of Wight, 1866. He is the son of the late Captain Cowper-Coles, R.N., C.B., inventor of the turret system for warships. Since the age of eighteen he has devoted much time to experimental science, and for the last seven or eight years has made a special study of electro-chemistry and metallurgy, the results of which have been the introduction of a process for the electro-deposition of a standard silver in the place of pure silver, the alloy consisting of cadmium and silver. This process has been extensively used for protective coatings for ship and bicycle fittings, and gained a silver medal at the last Crystal Palace Electrical Exhibition. Mr. Cowper-Coles' researches and experiments have also led to the introduction of electro-galvanising to shipbuilding yards for the zincing of torpedo-boat-destroyers and boiler tubes; also to a process for the manufacture by electro-deposition of parabolic reflectors for search lights for ship and coast defence. He is a Member of the Institution of Electrical Engineers, an Associate Member of the Institution of Civil Engineers. a Member of the Institution of Mechanical Engineers, a Member of the Royal Institution of Great Britain, and a Member of the Society of Chemical Industry. He is a contributor to some of the leading scientific papers.

PROJECTORS are now extensively used for naval and military operations, every man of war and torpedo-boat destroyer being supplied with one or more, as the power of rendering visible distant ships and bodies of men is of great value. They are also largely used by the mercantile marine and for the headlights of locomotives. The most essential part of the projector consists of optical means whereby the rays of some source of light are collected by reflection or refraction, or both, and projected in the form of a beam towards the distant object which it is desired to illuminate.

The efficiency of the projector depends :—

1. On the size of the useful angle, that is, the angle contained by the rays which are reflected or refracted by the extreme edge of the projector, this angle being the measure of the amount of radiation which is effected by the projector.

2. On the capacity to transmit the radiations with a minimum loss to the object illuminated.

3. On the nature of the source of the illumination.

If the light emanated from a point exactly the focus of a perfect parabolic mirror, the beam would be rendered absolutely parallel. In the case of the arc, however, the light comes from the crater of the positive carbon, which is of appreciable size, especially with large currents. Every point on the mirror is

Fig.1.

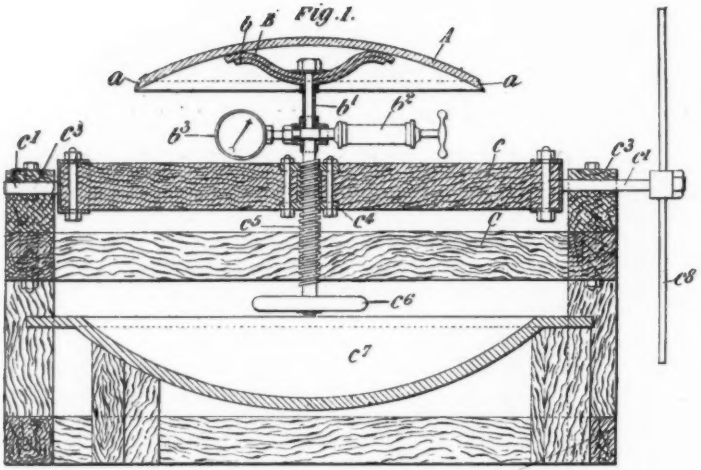

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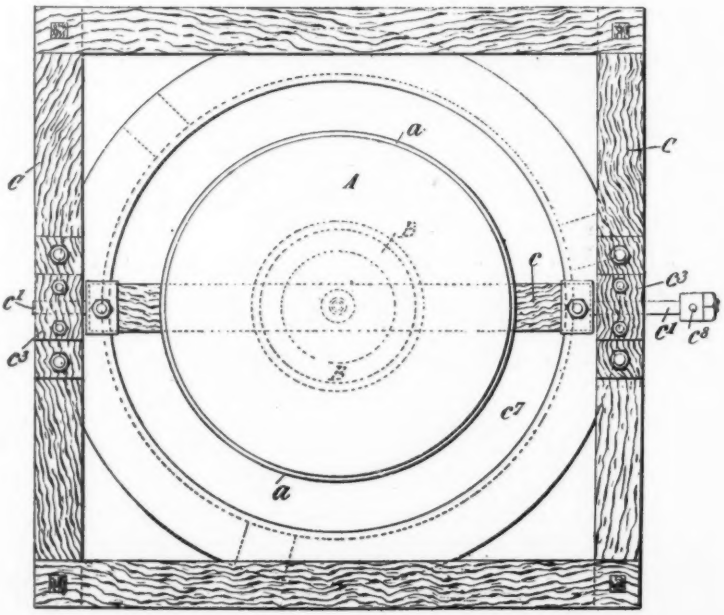
Fig.2.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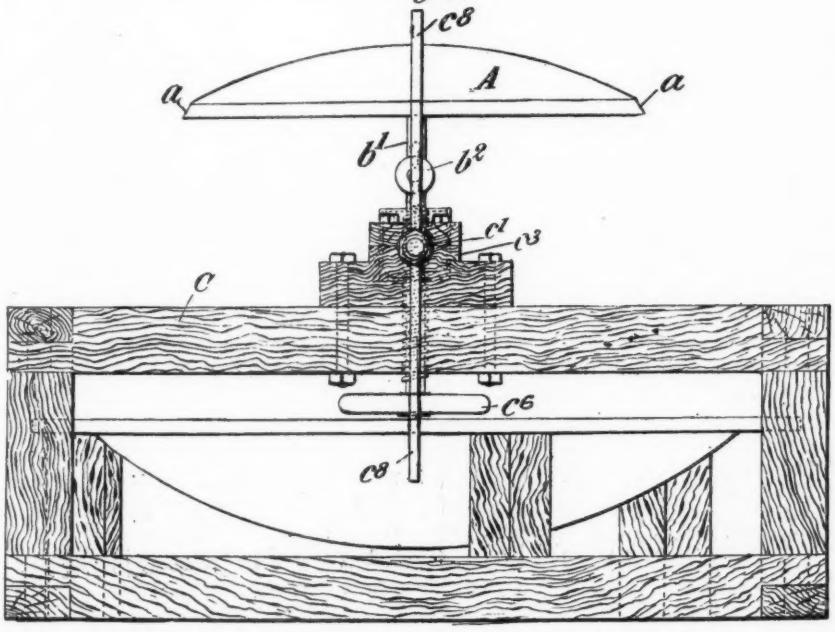
therefore struck with a cone of light, the angle of the cone depending on the size of the crater and the focal distance, consequently the whole beam, after reflection, disperses at the same angle. More light is collected from the crater of the arc, as any light thrown from the focus to any point of the curve is reflected exactly parallel to the axis. Light collected by a surface is inversely proportional to the square of the distance of the source of light, but after a certain limit has been reached, the amount of light received by the mirror does not continue to increase as the solid angle, on account of the obscuration effected by the walls of the crater. This obscuration begins to tell after a section of the solid angle has been reached of about 65°. The source of light of the point of a 1′ 0″ mirror of 1′ 0″ focus would be as good as a 2′ 0″ mirror with a 2′ 0″ focus, both taking the same solid angle of light. The dispersion of a Mangen mirror burning a 30 mm. positive carbon with 150 ampères is about 2° ; that of a Schuckert is about the same. The dispersion of a Schuckert is the same as a Mangen ; though the focal distance is less, the light collecting power is therefore greater.

THE ORIGINAL USE FOR PROJECTORS

was for lighthouses, parabolic mirrors of metal being used, the mirrors converting the rays falling on them into a parallel beam. These metal mirrors were finally abandoned on account of the difficulty of construction, and secondly, due to the fact that an untarnishable metal could not be found. The researches by Professor Potter give a loss of 31 to 35 per cent. for mirror metal, and Stevenson found for polished silver, an angle of 45°, that the loss was about 44 per cent. Many attempts have been made to produce a metallic reflector. One of the first ap-

Fig. 3.



pears to be that of Tony Pettijean in the year 1872, who employed glass moulds representing the mirror to be produced, which he coated by chemical means with silver by using a solution of that metal, to which he added one or several alkaline vegetable salts. Having thus deposited a film of silver, he continued to further deposit a coating thereon of the same or an inferior metal by electro-deposition. When the deposit had attained the desired thickness, he detached it from the glass mould, and the surface of the metal was found to have a polish corresponding to that of the glass. He also proposed using stearin, paraffin, or sealing wax as a mould. The next attempt seems to have been made by Dr. Alfred Readdel in the year 1889, who describes a method of making a reflector or a section of a reflector as follows :—He coated a convex reflector form or matrix made of iron or other suitable material with a coating of silver, on which he deposited a backing of copper. The copper was then coated with a layer of glue or other adhesive, preferably applied cold, on which was laid a coating of plaster of Paris, and lastly a coating of rougher plaster. When set, the whole was removed from the iron form or matrix and the silver surface polished. According to the invention of John Jacobson, of Mass., which was taken out in the year 1891, a mirror was produced having a polished surface as follows :—The surface of the glass mould was coated with silver by any of the usual processes, the necessary strength and rigidity being given to the silver film by applying cement or other suitable material in a plastic condition, with or without the subsequent addition of a film of a baser metal, such as copper.

Glass mirrors at the present time are almost exclusively used for projectors for search lights and similar purposes, although it is

A WELL-RECOGNISED FACT THAT A METAL REFLECTOR IS SUITABLE FOR MOST PURPOSES.

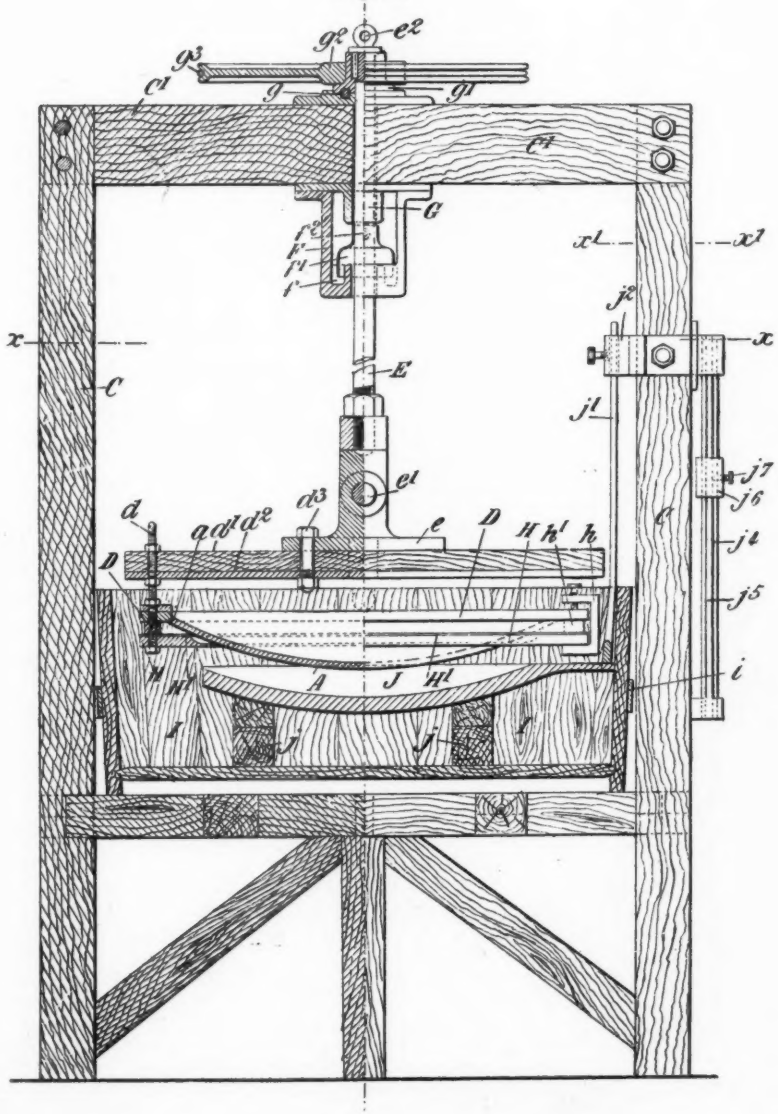
One advantage of a parabolic reflector is that the rays from the carbon points are collected into parallel beams by means of reflection only, and it is not catadioptric as most glass mirrors are. A perfect parabolic mirror of exact mathematical curvature ensures parabolism of the rays, especially if the source of the illumination is reduced to very small dimensions. Great difficulty has been experienced in producing a true metallic reflector that will not readily tarnish when exposed to the heat of an arc light and the influences of damp air and sea water.

Spun reflectors are never true, as it is found in practice impossible to spin them quite true to the moulds. Experiments have been made with a view to substituting cast metal for glass, but the cost of grinding and polishing, and the unsatisfactory surface that is obtained, have resulted in the attempts being abandoned. Stamped reflectors have also been tried, but with no more satisfactory results. The process now about to be described to you is an electrolytic one, one of the chief features being that the surface produced requires no after polishing or trueing up. When once a true mould has been produced any number of reflectors can be taken from it at a small cost. A glass mould is prepared, the convex side of which is accurately shaped and polished to form a true parabolic or other reflecting surface. As the mould only requires shaping and polishing on the convex side, it is comparatively cheap as compared to a glass reflector, which has to be ground on both sides.

The glass moulds are prepared as follows :—

First of all a convex cast iron mould is made to the approximate curve of the mirror. From this a concave mould is made of refractory material. Over this is laid a piece of flat glass about $\frac{3}{4}$ inch thick, and the whole placed in a furnace and heated to such a temperature that the glass will adapt itself to the curvature of the mould without fusing. The roughly-shaped glass mould thus prepared is then ground and polished on the convex side only. The mould is revolved and pads caused to move over the surface of it. The first cutting or breaking down operation is done by means of emery, the arm being given the right curvature by means of a template. This process is a very ex-

Fig. 4.


g2
e2
g3
C1
g
g1
C4
G
f2
f3
f4
f
x1
x1
j2
x
x
E
C
j1
e1
j7
j6
d
d3
e
D
H
H1
h
h1
j4
D
d1
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j5
i
A
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J

pensive and laborious one, taking several months, the larger mirrors alone taking two or three months.

On the prepared surface is deposited a coating of metallic silver which is

THROWN DOWN CHEMICALLY ON THE GLASS

and then polished so as to ensure the copper backing being adherent to the silver. The mould thus prepared is placed in a suitable ring and frame (which I will describe later on), and immersed in an electrolyte of copper sulphate, the mould being rotated in a horizontal position, the number of revolutions being about fifteen per minute. The copper adheres firmly to the silver, and together they form the reflector which is subsequently separated from the glass mould by placing the whole in cold or lukewarm water, and then gradually raising the temperature of the water to 120° Fahr., when the metal reflector will leave the glass mould due to the unequal expansion of the two. The concave surface of the reflector obtained is an exact reproduction of the surface of the mould, and has the same brilliant polish, and requires no further treatment to answer all the purposes of a reflector with the exception that it must be coated with a film of some suitable metal to prevent it tarnishing. Palladium is found to answer this purpose best, as a bright coating can be deposited rapidly to any desired thickness. The palladium resists tarnishing and the heat of an arc to a wonderful degree.

Palladium is a silver-white hard metal, and is sufficiently ductile to be rolled into thin sheets. Its specific gravity is 11·4, being about half that of platinum. The present price of palladium is about double that of platinum, but its weight being only one half, the same area can be covered at the same cost. Palladium is usually obtained by neutralising the solution (aqua regia) with sodium carbonate and adding mercuric cyanide, which precipitates it as palladium cyanide. This on ignition yields sponge palladium, which is one of the most convenient forms for making up palladium solutions. Palladium at the present time is somewhat a drug in the market, the price asked being quite a fancy one. Palladium is chiefly associated with other metals of the platinum group, and is found in small quantities in platinum sand. It melts at an extremely high temperature, about the same as wrought iron. When only slightly heated in hydrogen gas it has an extraordinary power of absorbing mechanically large volumes of this gas. Graham investigated this very peculiar phenomenon and found that a piece of palladium foil when heated below 212° Fahr. takes 240 times its volume of hydrogen, but that it has not the power of absorbing oxygen or nitrogen, the absorption of oxygen by palladium black being a process of oxidation. At a moderately high temperature palladium assumes a blue colour, due to the formation of a thin film of oxide, which it loses at a higher temperature due to the decomposition of the oxide. Palladium is not readily attacked by sulphuric or hydrochloric acid.

THE COMPARATIVE HARDNESS OF PALLADIUM

to other metals is shown in the following table :—

Nickel electro-deposited	10·0
Sheffield plate	10·0
Antimony electro-deposited	9·0
Palladium deposited bright	8·0
Chromium electro-deposited on copper	7·0
Cadmium deposited bright	4·5
Silver electro-deposited and burnished.	4·0

The figures give the hardness as represented by the number of grammes weight on a diamond point required to produce a scratch. Platinum and palladium possess a reflecting power inferior to that of silver for visual rays, but superior for chemical rays, and for astrophotography.

In carrying out the manufacture of reflectors by this process, it is essential that the glass mould be perfectly clean and free from grease before the coating is applied. It has been found, however, that if the cleaning is solely effected by chemical means, there is a great liability of the silver adhering too firmly to the glass, whereby the mould is in danger of being broken during the removal of the reflector. This difficulty has been overcome by cleansing the mould with a suitable paste or powder such as peroxide of iron, and then removing such paste or

powder by washing the glass with a 50 per cent. solution of ammonia. It is necessary that the cleaning operation be repeated prior to the production of each reflector. After the convex side of the mould has been properly cleaned as described, a thin coating of metallic silver is applied as follows: — Ammonia is added to a solution of nitrate of silver until the precipitate that is formed is dissolved, then re-precipitating with caustic soda, again dissolving in ammonia, then adding glucose to the solution. Excellent results have been obtained with a silvering solution made up of equal parts of solution of the following strengths: — silver nitrate, 0·55 per cent.; caustic potash, 0·25 per cent. The surface of the mould to be coated is immediately dipped into the solution face downwards. In from four to five minutes the silver begins to form on the glass mould, the solution changing from pink to dark brown and black; the film thickens quickly, and in from thirty to thirty-five minutes a good coating of silver is deposited. Dr. Common has found a good deposit of silver to be equal to a thickness of $\frac{1}{2 \times 1000}$ inch. The silver is found to be clearer, thicker, and more uniform if the glass mould is dipped into a proto-chloride solution of tin and then washed before being placed in the silvering bath; the action is supposed to be catalytic. The silver coating is thoroughly washed, and then allowed to dry, and the silver which has been deposited is burnished bright with a piece of cotton

FIG. 5.

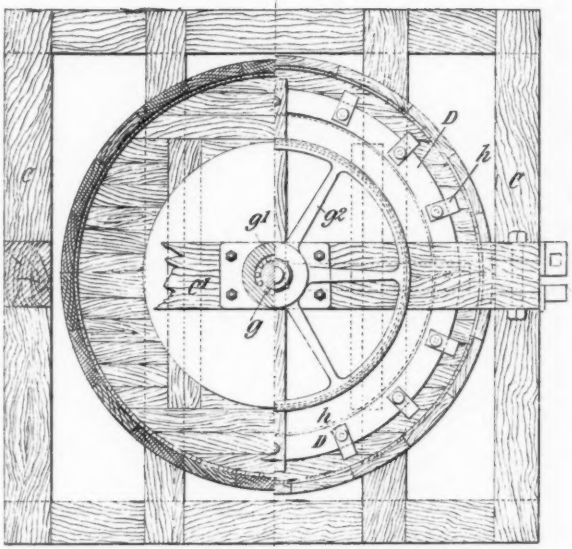
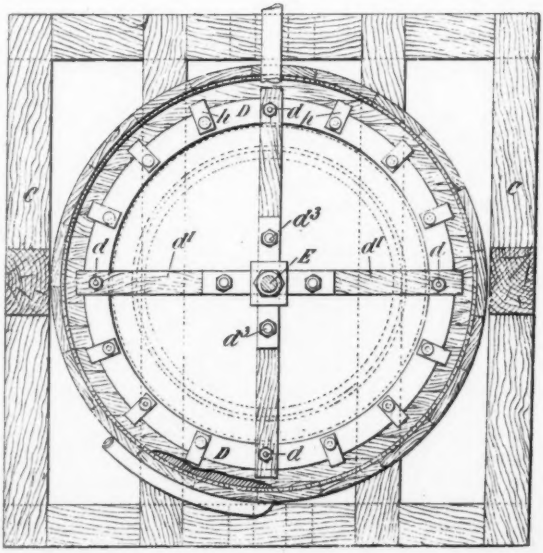


FIG. 6



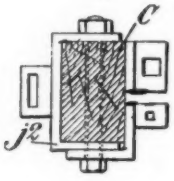
F 2

wool and peroxide of iron, preferably precipitated by ammonia from a dilute solution of ferrous sulphate.

The cost of silvering is found to vary from 2d. to 4d. per inch diameter.

Some interesting experiments have lately been made in America on the conductivity

Fig. 7.



of thin films of silver deposited on glass by the Rochelle Salt Process. Many experimenters have endeavoured to construct portable standards of high resistance by means of lines or films of black lead, and have discovered how unstable such devices are. In the paper referred to, in each case the thickness of the film was calculated from the area and mass of the deposited silver, assuming its density to be that of solid silver, and a resistance was given corresponding to that thickness, the films being 10 cm. long and 1 cm. wide and varying in thickness from one to twenty-two millionths of a cm. Two results were obtained. Firstly, the measured resistance is always enormously higher than that calculated, being in one case more than one hundred thousand times as great ; and secondly, the resistance of the film always drops rapidly after formation and continues to do so for an indefinite time except in the case of very thin films, which could not be very permanently maintained, and some few whose resistances, after a few days, began to increase. The changes are rapidly accelerated by heat. The experiments appear to show that the metal is deposited in an only partially coherent condition, and gradually settles down into a more compact mass.

A film of silver and copper stripped from a glass mould is quite transparent to transmitted light, having a green tinge, but is capable of reflecting light.

REFERENCES TO ILLUSTRATIONS.

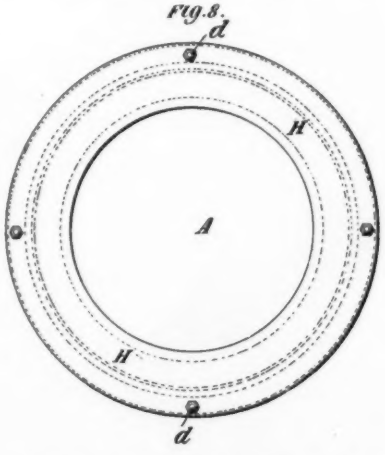
In the accompanying drawings, Fig. 1 is a sectional elevation, and Fig. 2 is a plan of a washing or silvering tank. Fig. 3 is a side elevation at right angles to Fig. 1. Fig. 4 is an elevation, partly in section, of a copper-depositing vat and its connections. Figs. 5 and 6 are a top plan partly in section, and a plan on the line x, x, respectively, of Fig. 4. Fig. 7 is a sectional plan on the line x^1, x^1, Fig. 4. Fig. 8 is an inverted plan of the mirror and annular baffle plate shewn in Fig. 4. Fig. 9 shews an elevation at right angles to Fig. 4 of the rod E and its connections. Fig. 10 is an elevation at right angles to Fig. 4 of the electrical resistance. Figs. 11 and 12 are enlarged views of details hereinafter referred to.

Figs. 13 and 14 are a side elevation partly in section, and an end elevation, respectively, of a platinum, chromium or palladium depositing tank.

Fig. 15 is a plan of the apparatus shown in Figs. 13 and 14.

Referring to Figs. 1 to 3, A is the mould accurately shaped on its convex side to a true parabolic or other curve and formed with a bevelled edge *a*. B is

Fig. 8.



a circular concave sucker formed by a disc of rubber, leather, or other suitable substance, backed with metal plate *b*, and

attached to one end of a tube b^1, which communicates with an exhaust pump b^2, and vacuum gauge b^3, and has its other end attached to a screw rod c^5. c is a rotary wooden bar having metal journals c^1 attached to its ends. These journals

Fig. 9.

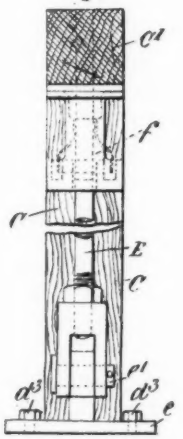
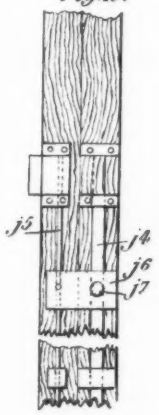


Fig. 10.



are mounted in suitable bearings formed by plummer blocks c^3, attached to the frame C. A hole is bored through the centre of the bar c at right angles to the longitudinal axis thereof, and an internally screw-threaded metal bush c^4 is fixed therein. The screw rod c^5 engages with this bush, and has a hand wheel c^6 attached to its free end. c^7 is the tank containing the washing or silvering solution. When required for use the bar c is rotated by means of the hand-wheel c^8 until the sucker B is turned up into the position shewn. The concave side of the mould A is then placed on the sucker, and the air exhausted from between the said mould and sucker by means of the exhaust pump, and the mould thus securely attached to the apparatus. When in this position the convex surface of the mould is coated with wax. If the mould is of glass, it is cleansed (preferably by washing with a weak solution of ammonia) before being coated with wax; it is then, by means of rotating the bar c, turned down into the tank c^7, when its convex surface is submerged in a suitable silvering solution and coated with silver. If the mould is composed of speculum metal the mould is not coated with silver, as it can itself act as the cathode in the subsequent operations.

The mould is now removed from the sucker and (referring to Figs. 4 to 12) placed so that its bevelled edge a fits accurately into the corresponding inner bevelled edge of the metal ring D, which serves to support it in the depositing tank l, while the metal backing of the reflector is being deposited thereon. The ring D is suspended by metal bolts d from wooden cross bars d^1, the lower surfaces of which are lined with brass strips d^2. These cross bars and brass strips are connected by metal bolts d^3 to a metal flange e, forming a base to which is hinged the vertical shaft E by means of a pin or pivot e^1. This shaft E passes through a box F, and is carried on the horizontal bar C^1 on the main frame, by means of a bearing G, having balls g, which support the shaft by a collar g^1, and allow it to rotate freely. g^2 is a pulley through which the shaft E and the mould A may be rotated freely by a belt or cord g^3. A metal box F is fixed to the under side of the bar C^1 on the main frame, and con-

Fig. 11.

Fig. 12.

tains an annular mercury trough f in which is submerged the edge of a cup f^1, secured to the shaft E by means of the set screw f^2. Attached to the ring D by means of the clamps h, are an annular baffle plate H, and an annular stopping off

plate or ring H^1. The distance of the plate H below the ring D is regulated by the thickness of the blocks h^1. The object of the baffle plate is to prevent the formation of "trees" or nodules at the edge of the mirror, and the object of the cutting off ring or plate is to determine the exact size of the mirror. Situated also in the tank l is the anode J, which (if a copper backing is being deposited on the mould) is of copper. This anode rests upon packing blocks j, and has a vertical rod j^1 attached to it, the free end of which is adjustably secured in the metal bracket j^2 attached to one of the side members of the main frame. By means of adjusting this rod j^1 in the bracket j^2, the distance between the anode and the mould or cathode may be regulated. The tank l is fitted with a suitable inlet and outlet for the supply of electrolyte, and one electric terminal is connected to the box F, electrical connection being made by means of the mercury trough f, shaft E, bolt d^3, plate d^2, and bolt d, to the mould forming the cathode. The other electric terminal is connected to a resistance, hereafter referred to, which is connected through the bracket j^2, and rod j^1, to the anode. This resistance consists of a rod j^4, which is a good conductor, and a rod j^5, which is a comparatively bad conductor, suitably attached to a wooden side member of the main frame, one end of the rod j^5 being in electrical connection with the bracket j^2. These two rods are connected by a bridge-piece j^6, adjustable by means of a set screw j^7, and one of the electric conductors is connected to one end of the rod j^4. By means of shifting the bridge-piece j^6, the length of the rod j^4, through which the current has to pass before reaching the said bridge-piece, will be increased as the length of the rod j^5, through which the current has to pass from the said bridge to the bracket j^2, is decreased, *vice versâ*, the current being thus regulated.

If required, the frame d^1 and the mould may be tilted on the pivot e^1, and if this pivot be removed, these parts may be together removed from the tank. By means of a cord passing over a pulley and connected to an eye or ring e^2 on the free end of the shaft E, the said shaft may, when the set screw f^2 is removed, be drawn up and the mould thus lifted from the depositing tank.

The tank is strengthened by a metal band or bands i which pass round it. The ends of these bands are screw threaded, and after passing respectively through the ends of a ring bar i^1, are fitted with the nuts i^2, by means of which the band can be tightened.

After a sufficient thickness of metal has been deposited on the mould to form a suitable backing for the reflector, it is removed from this tank and the reflector backing removed by heating, when the difference in expansibility will cause the backing to separate from the mould. The concave surface of the backing is now chemically cleaned, preferably with potassium cyanide or hydrate, and the backing then (referring to Figs. 13 and 14) placed in an earthenware pan I^1, adapted to fit it, where a reflecting and protecting surface of platinum or palladium is deposited upon it. The pan I^1 is supported on a suitable frame, and its height can be regulated by the screw jack K. A suitable anode is suspended from the main frame above the pan I^1. This anode consists of a number of carbon plates or sheets M fixed in a holder m by means of lead strips m^1. The edge of this anode is arranged to form a curve approximate to that of the mould. The holder M is attached to a swinging frame m^2, mounted so as to be capable of sliding longitudinally on the block L pivoted to the pin l, supported from the main frame by the hangers l^1. An internally screw-threaded block l^2 is supported by arms l^3 from the pin l. One end of the screw-threaded rod l^4 engages with this block, and the other end of the rod l^4 passes through a clear hole in the bracket m^3 fixed to the frame m^2, and has a hand wheel l^5 attached to the extremity thereof. l^6 and l^7 are collars fixed to the rod l^4, one on either side of the bracket m^3, in order to prevent any longitudinal movement of the said rod through this bracket. It is obvious that by turning the hand wheel l^5 the height of the anode above the reflector can be regulated. One end

of the connecting rod N is pivoted to the frame m^3 at n, and its other end is pivoted to a revolving disc O. In the disc O is a radial slot o in which the pivot carrying the connecting rod is adjustable, so that by shortening or lengthening the distance between the said pivot and the centre of the disc the throw of the connecting rod can be regulated. The disc O is connected to any convenient source of power by band and pulley gear P. The electric terminals are attached respectively to the metal backing forming the cathode, and to the frame carrying the anode M. If

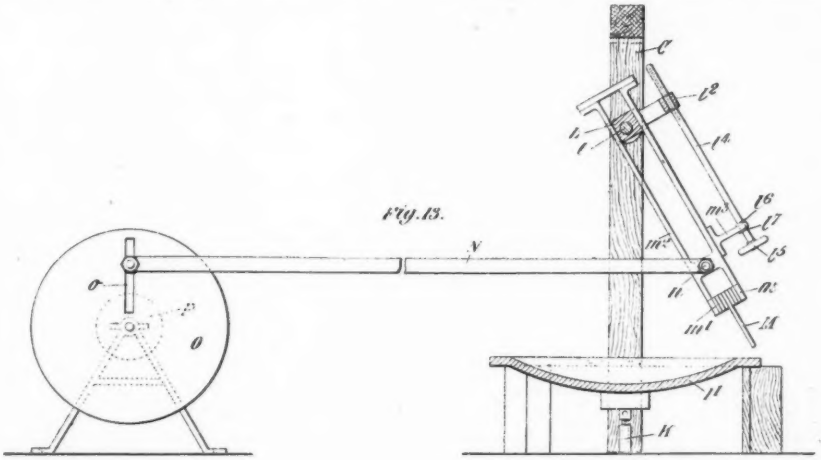


Fig. 13.

the reflector is to have a reflecting and protecting surface of platinum the tank l^1 is filled to a sufficient depth with a solution of platinum composed of freshly precipitated double chloride or platinum and ammonium dissolved in a boiling concentrated solution of neutral citrate of sodium. And if the said reflecting and protecting surface is to be composed of palladium, a solution of palladium ammonium chloride may be used; or if the surface is to be of chromium, a suitable chromium solution is used.

During this last electrolyzing process the anode M is caused to swing backwards and forwards through the electrolyte by means of the revolving disc O, in order to obtain an even deposit over the whole surface of the reflector, to keep the electrolyte agitated and prevent the deposition upon the reflecting surface of any foreign matter suspended therein.

Seventy to eighty grains of palladium to the superficial foot is found to afford a good protective coating. The silver-faced reflector previous to being placed in the palladium solution is thoroughly washed with a weak solution of caustic soda.

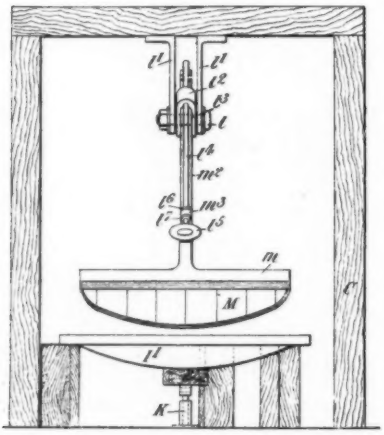
The back of the reflector is usually varnished before placing it in the bath to prevent local action setting up between the copper and silver and palladium. The reflector is removed from the bath and dipped in boiling water, and then placed in boxwood sawdust, which is kept hot by means of a steam jacket. The reflector is then ready to be mounted in a suitable ring, such as shown in Fig. 16. The clamping ring shown in the figure is provided with a knife-edge, marked F, Fig. 16. The knife-edge forces the reflector against a ring of asbestos, which is placed in a groove marked G, and retains it in position after the reflector has been carefully centred, whilst resting on the asbestos ring.

REFLECTORS MADE BY THE PROCESS

which has just been described have been subjected to a number of tests, and found

to stand excessive heat without tarnishing. Salt water has been thrown on the reflectors when they have been too hot to touch, the result being that the water was

Fig. 14.



driven off as steam, and the salt left as a white deposit upon the reflector, which was easily removed with a wet cloth.

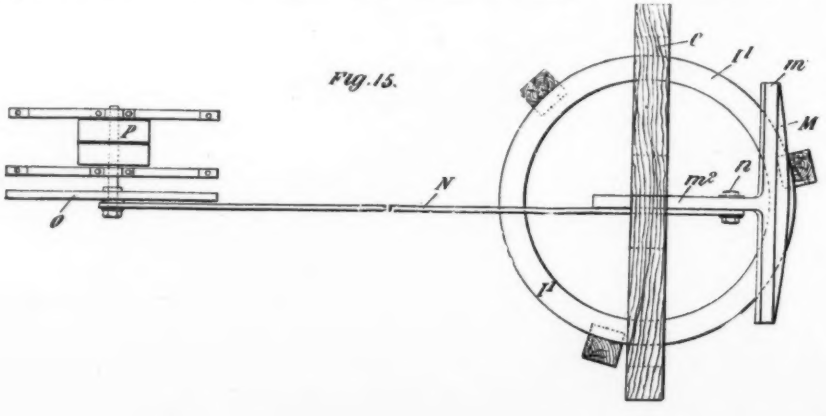
A reflector recently tested at Portsmouth had a number of rifle bullets passed through it, when the beam was found to be little affected. On the other hand, the first shot fired at a glass reflector splintered it to pieces.

Although palladium does not reflect light as well as a silver surface which is perfectly clean and bright, silver is found to be quite unsuitable, as after being in close proximity to an arc light for a short time, the silver tarnishes and the light is greatly reduced in intensity. Palladium gives a very white reflection, as white, if not whiter, than that obtained from silver. With a palladium-faced reflector the intensity of the light is found to remain practically constant, as little or no tarnishing takes place. Nickel has been found quite unsuitable.

The weight of a 36″ mirror is about 29 lbs., and the weight of the ring 132 lbs., making a total of 161 lbs.; whereas the weight of a glass mirror is 165 lbs. without mounting.

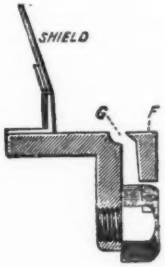
Some of the reflectors have been tested optically by the process which has been extensively used by Tchikoliff. The method consists in photographing the image in a reflector of a white screen covered with a black square network, as shown in Fig. 17, the lines being 0·2 in. thick, and 0·6 in. apart. In the centre of the screen a square opening is left, through which the photograph of the image of the network is taken through a pinhole. The first steps in the process are as follows:—The reflector is placed at a distance of from 3 to 5 ft. from the screen, which should exceed by at least 35 per cent. the height and breadth of the reflector, so as to ensure the image of the network covering the whole surface of the mirror. The test of the reflector is carried out as follows:—The surface of the

Fig. 15.



mirror in all planes is tried by a template to ensure that the exterior curves of the surface are not far distant from the parabola; the image on the screen is then

FIG. 16.



photographed, and the irregularity of the lines indicates any serious errors of the parabolic surface.

Some 3′ 0″ mirrors made by this process were placed in a projector case in which was worked a 175 ampères lamp, for six hours, during which time the temperature at the top of the reflector was found to be about 540° Fahr.; on removal the palladium was found to be quite bright, with the exception of a few stains, which were readily removed with a chamois leather.

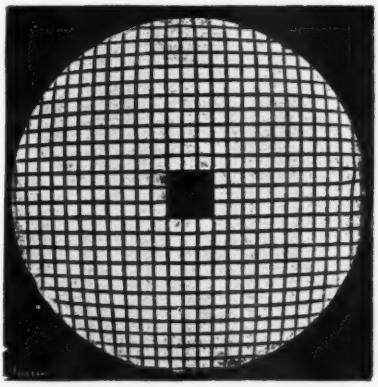
These mirrors were also tested by

THE GOVERNMENT TEST,

that is, placing a number of annular rings of different diameters in front of the mirror and reading on a scale the comparative focal length of the exposed portion of the mirror, an arc lamp being placed for this purpose at a distance of 150 yards. The results obtained were most satisfactory.

Messrs. Blondel and Rey have deduced from theoretical considerations that the brilliancy from any point of surface of the mirror, or of a mirror projector of the form due to Mangen, is practically constant, each point being considered as a source of light, and its brilliancy being measured in the direction of the optic axis of the mirror. They have recently tested this experimentally, and find that the brilliancy is constant except at the

FIG. 17.



edge of the mirror, and the central portion, which is hidden by the negative carbon. To determine the brilliancy at any point of the surface, a sheet iron screen was introduced at a short distance in front of the projector so as to cut off all the rays, except those coming from a small area surrounding the point. These rays were passed through a small hole in a sheet iron screen, and formed an image of a crater on a photometer screen interposed at some distance. The illumination at the centre of this image was measured, and the brilliancy at a point of the mirror calculated. Finding the brilliancy at each zone of the mirror, the total candle power of the projector is easily deduced.

John Lumpur-Lobo

Machine Tools.

By EWART C. AMOS, M.I. MECH.E.

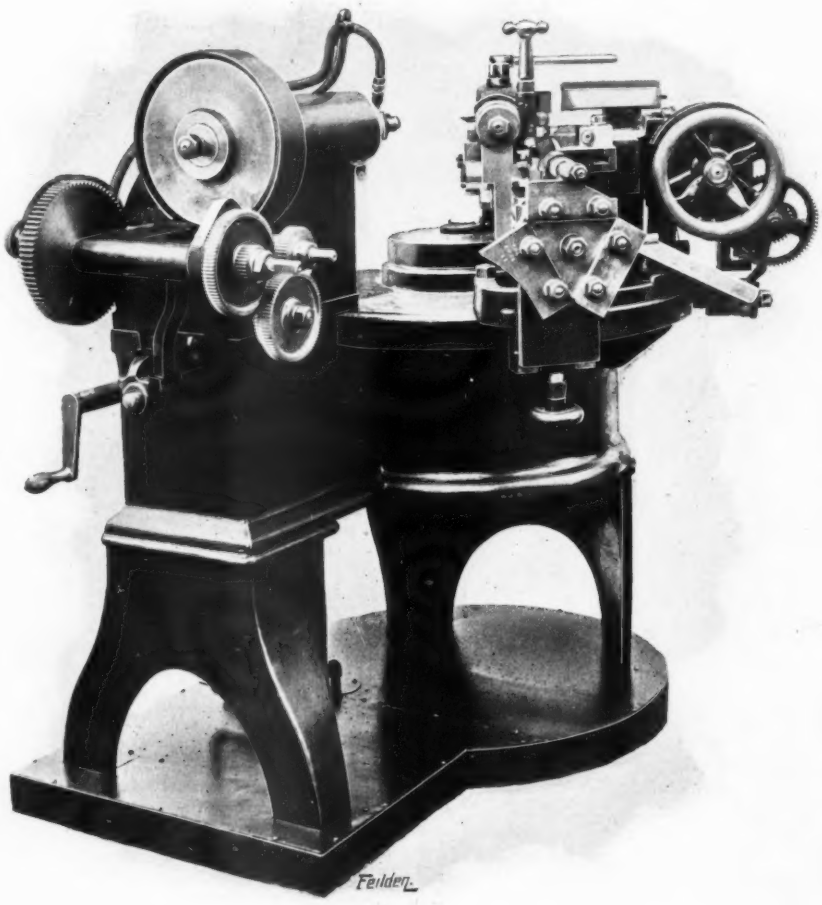
General Remarks illustrated by some English and American Machines.

MR. EWART C. AMOS, M.I.Mech.E., the author of the articles on "Machine Tools," now commencing in this Magazine, has made a specialty of the subject, having given close and considerable attention to it during the past twelve or fourteen years, a period when probably the greatest changes have taken place that have occurred in this industry. Mr. Amos served his time in a London shop, and joined the Institute of Mechanical Engineers as a graduate in 1885, being elected a full member in 1891. In 1893 he read a paper on Machine Tools before the Civil and Mechanical Engineers' Society in London, which attracted considerable attention at the time. He foreshadowed the probability of American encroachment and competition when, comparatively speaking, they were only just beginning to be felt so far as tools were concerned. This year he read an important paper on the same subject before the Society of Engineers at the Royal United Service Institution. In this case, as before, his paper is being re-published by a number of our contemporaries, and has also received notices from nearly all the technical journals in the Kingdom. Mr. Amos has not, however, confined his attention entirely to Machine Tools. He acted as one of the judges of the machinery exhibits at the late Italian Exhibition in London; he has also been an examiner at the Crystal Palace School of Engineering. The autocar movement, the manufacture of calcium carbide, petroleum gas furnaces, and other modern enterprises have at various times occupied his attention

THE Engineering Industry has probably never been in such a prosperous condition as it is to-day; nor is this state of affairs confined to our country alone. The buying capacity of the world generally has increased out of proportion to its manufacturing powers in so far as engineering output is concerned, with the result that all the best engineering firms are full up with orders which it will take them some time to execute. This has been going on now for some few years, and there is every prospect of its continuance. Whilst these remarks have been directed to the Engineering Industry as a whole, they apply as truly to the subject of these articles, viz., Machine Tools. In fact it is entirely due to the great progress made in the design and construction of Machine Tools, that it has been possible to comply with the present great demand for machinery. It may be argued, of course, that engineering enterprise has encouraged the making of present-day tools, but whether this or the former view be taken, the great importance of the question is beyond dispute; and bearing in mind the direct relation which the machine tool industry bears to general manufacturing, it is of far reaching consequence that we do not lag behind in the construction of what may be termed

THE MAINSPRING OF ENGINEERING,

and also of an industry of which Great Britain was undoubtedly the founder.



AMERICAN AUTOMATIC BEVEL GEAR PLANER.

No article on Machine Tools would to-day be complete or interesting if it did not refer to American Tools. Whatever views may be held as to the value of American machines (and there is still considerable difference of opinion on this point, notwithstanding the large quantity of these tools in use in this country), it will generally be admitted that our foreign competitors have introduced a number of novel and useful improvements, many of which are being extensively adopted by our more enterprising manufacturers at home. In order to make a fair comparison between ourselves and our com-

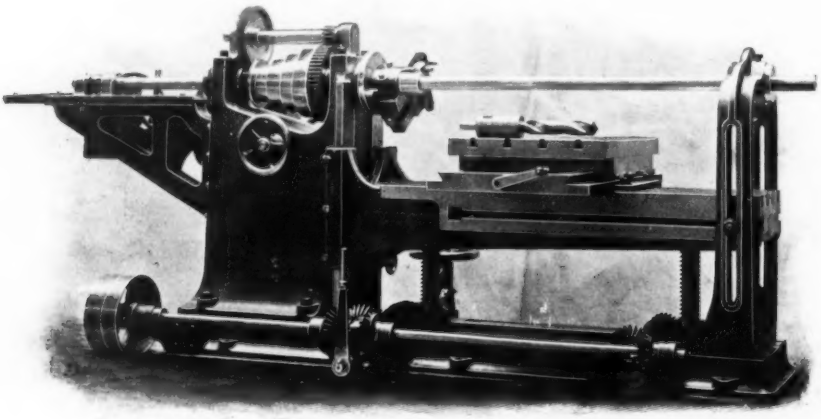
petitors, and especially our American friends who are at present the keenest, it is necessary to consider the subject under three heads, viz :—

(1.) Design, having special reference to the idea, action, or shape of a machine.

(2.) Method of construction, especially in regard to strength, distribution of material, and weight.

(3.) General management of machines, and workshop practice.

It may be noted with interest that whilst we may to some extent be inclined to follow them under the first heading, we are not so disposed to alter our views under the second. In other words, we are embodying the good ideas and designs without sacrificing solidity to outline as so frequently occurs in American practice. Under the first heading also may be considered the question of Automatic Tools, a class of machine which is at the bottom of America's success, and without which she could not come near us in respect to prices.



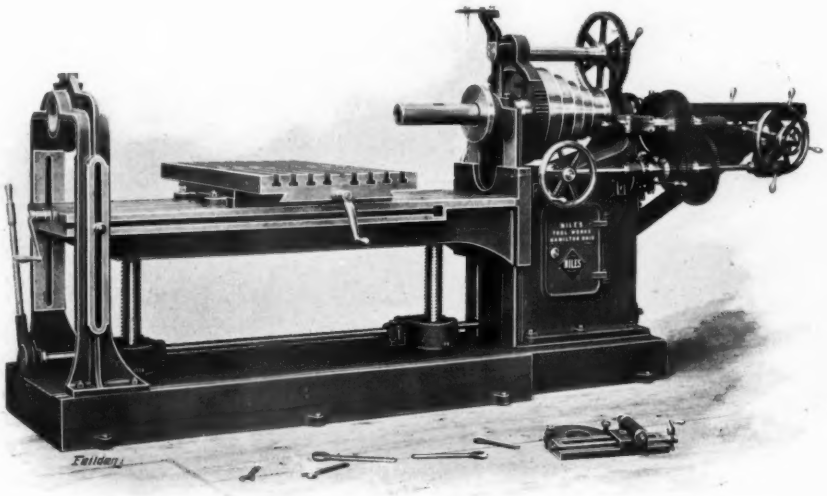
BRITISH BORING MACHINE.

WHY DO WE NOT ENCOURAGE THE AUTOMATIC MACHINE

to the same extent? There is probably more than one answer to this question, but the first one that occurs is, that the present position of our labour question is against the extensive use of those machines which require little attention and unskilled artisans to work them —no doubt this is a transitory state of things, which in the near future will find a solution alike beneficial to the operator and employer. When it is fully recognised on all sides that large production and high wages are possible, and that controlled production does not always control wages, then and only then, will the automatic machine be of the greatest value. On the other hand, the old idea, so prevalent in this country and in Europe generally, that machinery should assist rather than supplement the skilled worker, has its advantages, and enables the European to completely oust the American from the market in those products which still are and probably always will be dependent upon skilled labour. Moreover America has before her some big problems to solve in respect to labour, and it is not unlikely that we shall have solved them first, and on lines of a permanent character. Certainly they will not be in the direction of Trusts, which are sure to give our friends across the water a considerable amount of trouble before long. Referring back once more to the headings, it must be admitted that

WE HAVE BENEFITED BY THE ADOPTION OF DESIGN

and to some extent by alteration in construction, although English manufacturers could probably teach American makers something in respect to rigidity and solidity. But however much we may adopt American ideas, or purchase American Machine Tools, we shall not be able to achieve a like success to that obtained on the other side until we have altered our system of shop management, and methods of manufacture.



AMERICAN BORING MACHINE.

Reference is here especially directed to the question—so often ventilated of late—of manufacturing in quantity one or two specialties rather than of making a great variety of single machines. In America, the tool maker studies the manufacturers' requirements, and having ascertained them, he makes a dozen or more machines of the particular tool required. In this country we wait for the manufacturer to say what he wants (which by the way he very seldom knows), and then we make one machine, probably not of a standard type; and when a second machine is required later on, the cost of its production is nearly as great as the first.

It may seem paradoxical, but nevertheless it is a fact, that the prosperity of so many of our manufacturers is detrimental to extended enterprise, whilst the Government are also to some extent responsible for this state of things. They continue to ask for and appear satisfied with a class of tool that is getting obsolete; and manufacturers, with an eye to present profits, are naturally content to execute these orders, which do not involve any great change in their pattern department. Things, however, are rapidly altering, and where the English makers have attempted to combine the best American ideas with English practice, the results have been exceedingly satisfactory. One of the most important changes that has taken place, and a practice now becoming fairly universal amongst English makers, is the substitution of

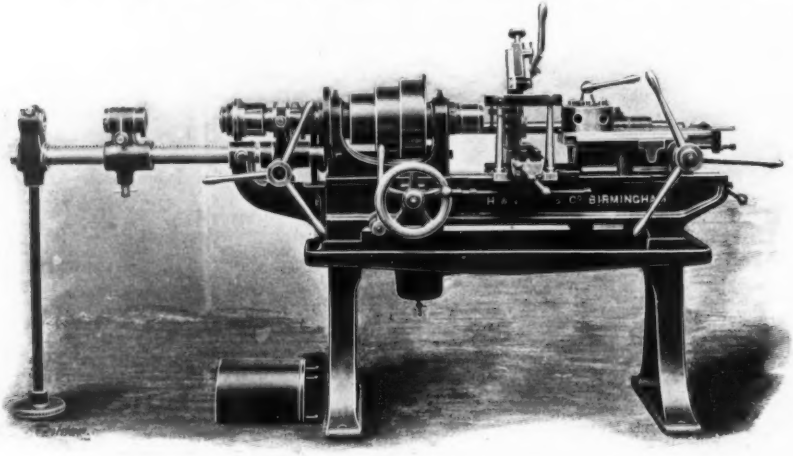
MACHINE CUT FOR MOULDED TOOTH-WHEELS.

This, of course, has been done by a few of the best makers for a very long time past, but it has been nothing like universal until quite recently. On the other hand, it is of the greatest rarity, and always has been, to find an American tool (on this side at any rate) with moulded teeth. It may be of interest here to refer to the illustration of an American automatic bevel-gear planer. These machines are entirely automatic, and will finish the work without any scraping or setting. Makers in this country more generally use milling cutters as being faster in action, but when this is done it is necessary to set the teeth after leaving the machine, as a small piece is left on which cannot be got at by a milling cutter. The gear in these machines is mounted so that its cone-lines meet at the centre of the machine, and the arm along which the tool-slide travels is swung round until the pointer indicates it is on the pitch-line angle of gear; as the tool is therefore always travelling towards the centre of the machine, the small end of tooth is in exact proportion to the large end.

The slide which carries the tool-holder has a quick return. The particular machine illustrated will take wheels up to 24″ diameter, 2″ pitch by 6″ on face, and anything under, down to very small gears.

Reference may be also made here to the two boring machines which are built on similar lines, one in England and the other in America. The design and capacity of the two tools are pretty much alike, and it may be stated, without detriment to either maker, that they are equally good—in fact, the selection would largely be influenced by whether you were English or American.

Another class of tool illustrated in this article is the Capstan lathe. Here, also, an English and an American make is shown, and again it is unnecessary to draw any comparison. In both cases the machines are fitted with a wire feed and chasing apparatus, although, in the American, the latter is placed on the top, instead of at the back of the headstock, which has the advantage of being out of the way. This class of lathe will be referred to more extensively in future articles, as it has of late years leapt into considerable prominence, and in various forms is one of the best automatic tools that we have.

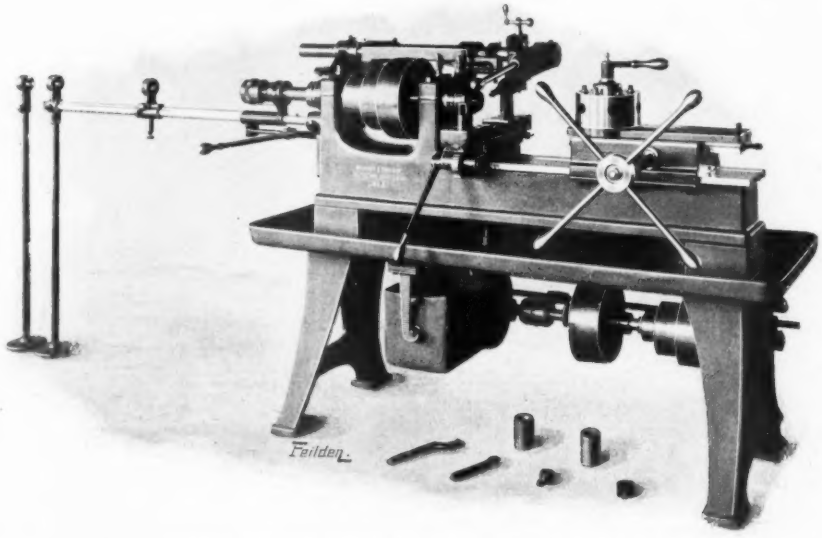


BRITISH WIRE FEED CAPSTAN LATHE, WITH SLIDING SADDLE AND CHASING ARM.

The tool industry is making very rapid strides, and the developments in the near future will be considerably influenced by

A MORE EXTENDED USE OF ELECTRICITY AND PNEUMATICS.

It is the purpose of these articles to refer to some of the most striking novelties, both of our own and our competitors' manufactures, and to point out their practical advantages in a fair and impartial manner. British tool-makers will lose nothing by looking into the causes that have made it possible for their present competitors to secure such a hold on the market as they have, and, in fact, whilst it is fully admitted that our capacity for making high-class substantial tools is in no way changed, yet, in the author's opinion, considerable alteration will have to be made in certain directions if we are to retain our position as the leading tool-makers of the world.



AMERICAN WIRE FEED CAPSTAN LATHE, WITH CHASING ARM ON TOP.

(To be continued.)

H. Adams

Copper Steam Pipes.

By W. EDWARD STOREY.

MR. W. EDWARD STOREY, of Messrs. Isaac Storey and Sons, Cornbrook, Manchester, may justly be ranked as an authority in the trade of Demetrius, who was a coppersmith. Over twenty years of practical experience in the manufacture and manipulation of copper pipes under varying pressures and conditions entitle him to speak with special knowledge of their adaptability and behaviour.

"GIVE a dog a bad name and hang him," says the old saw. It may be that this policy lacks something of justice, and reminds one of the course of legal procedure across the water which has aroused much indignation in the English breast. Nevertheless, it found acceptance at the hands of the Naval Architects at their Easter meeting this year, and copper as a material to be employed in the manufacture of steam pipes was their unfortunate victim. As the accused was not represented in court, a means is here and now sought to place the main points of its defence on record.

The subject was brought forward by Mr. J. T. Milton, Chief Engineer-Surveyor to Lloyd's Registry, who contributed a paper on "Steam Pipes," and an extremely interesting paper it was. It is, perhaps, unfortunate for the effect of this paper in superseding copper by steel for steam pipes—if that was Mr. Milton's object — that the same number of "Engineering" which contained the text of his paper, contained also a report of the evidence given in the enquiry as to the accident on H.M.S. "Terrible." This accident was due to the bursting of a welded steel boiler tube, the third which had so burst in the short voyage from Gibraltar to this country.

But, although sounding

A NOTE OF WARNING TO ENGINEERS

who are responsible for the design of pipe arrangements, and who have in many cases deemed it unnecessary to provide any new safeguards while using copper steam pipes under modern conditions of high pressure and temperature as additional to what were considered essential in earlier times, Mr. Milton does not condemn copper pipes as such. It is instructive to read that, in the many cases of explosion and accident which he cites, it is not on the material nor on the coppersmith, but on the engineer that the blame of the failure must fall. In the appendix to his paper, Mr. Milton cites sixty-eight cases of accident to steam pipes which have been investigated by the officials of the Board of Trade; of these, thirty-eight, or more than half the total, were due to insufficient provision for expansion and contraction, and the motion due to vibration; in fourteen cases there was no provision for draining away the water of condensation from the steam pipes. The accidents forming this list have all occurred

in the period from 1885 to the present time.

By many engineers it is considered that copper pipes possess an infinite capacity for sustaining bending stresses. This does not apply to marine engineers only, and in them this fallacy is perhaps more excusable than in the engineer dealing with stationary installations. For in ships the space is so often limited, and the ranges of pipe are so short, that severe bends cannot always be avoided. But it is not at all an uncommon thing for long ranges of iron or steel steam pipes to be fitted with copper bends of very short radius, and to be otherwise absolutely unprovided with means for taking up the expansion. It is to be supposed that the draughtsman has been carefully bred in the idea that copper is an expensive luxury, and its use must be curtailed to the smallest limits possible. Be this as it may, it is an extremely common occurrence for drawings of pipe ranges to be issued to the coppersmith with the centre radii of the bends as short as from one to one and a-half times the diameter of the pipe, and the flanges fixed as close up to the curve as possible. It is obviously impossible to rely upon such a bend to take up any considerable amount of expansion, and it is design of this kind that has led to so many and so serious accidents with the use of copper.

THE RISK HAS BEEN GREATLY INCREASED

of late by the increase which has generally taken place in the steam pressures and temperatures. It is still, however, quite possible so to arrange things that copper steam pipes can be used with perfect safety and, as no doubt will be admitted by all engineers who have the erection of steam machinery in their charge, since copper has so many points of advantage over cast-iron, wrought-iron, or steel as a convenient material for expansion pipes, making-up pieces in long ranges, and so forth, it is as well to know one or two points to be observed or avoided so as to obtain the best results.

There are at least three questions that call for special consideration—it is difficult to say which is the most important—and they are as follows:—1. Is it possible to avoid brazed seams by the exclusive use of solid-drawn copper pipes? 2. What is the safest method of attaching flanges to copper pipes? 3. What are the minimum radii to be allowed in the bending of copper pipes? As all these points are almost equally important, it does not much matter which is treated first, so they shall be taken in the order named.

It is not generally known that seamless copper tubes can now be obtained of almost any size for which there is a demand. The large sizes, from say 10 to 15 ins. bore, are somewhat expensive, but the cost is not so much as might appear at first sight, as there is always the value of copper ingot of equal weight in the pipe should it ever be necessary to realize it, a fact that should be borne in mind when comparing the cost of copper with that of steel pipes. It cannot, however, be too strongly insisted on that all seamless copper pipes are not suitable for steam purposes. None but drawn pipes should be used; it is absolutely essential to the uniform strength and ductility of the copper that it should pass through some process of manufacture which puts work on the material equivalent to that it undergoes in drawing through a die. Copper has suffered not a little in the opinion of users, and particularly of seagoing engineers, because of the repeated failures of material which has not undergone the process of manufacture above alluded to. As bearing on this point, it is interesting to know that one of the most prominent of the ship-owning companies of the continent specifies that the copper used in the manufacture of its steam pipes must not be electrolysed, and it appears to be the experience of one of the leading makers of copper tubes that electrolytic copper, even after undergoing the drawing process, is not nearly so satisfactory in use, because of its crystalline structure, as copper refined in the ordinary way. Experience of the danger, trouble, and anxiety due to

FAILURE OF COPPER PIPES WHEN AT SEA

naturally results in the condemnation of copper as a material for steam pipes, with-

out consideration of whether the fault is not perhaps in the particular quality of copper used, or lies even at the door of the contracting engineer's drawing office, and does not attach to the material at all.

The fact that such large seamless drawn copper pipes can now be procured, makes it no longer necessary to use brazed pipes in main steam ranges, if only the price does not rule the matter, and if, where bends are required, reasonably long radii are allowed. But of this latter point more anon.

Eliminate the brazed seam from copper steam pipes, and at once the risks of damage in manufacture are reduced to the vanishing point. There can then be no fear of the electrolytic action described by Professor Arnold in his report on the burst pipe from the S.S. "Prodano." The pipe is pure copper from joint ring to joint ring, and as such can resist corrosive action better than any other material it is possible to use.

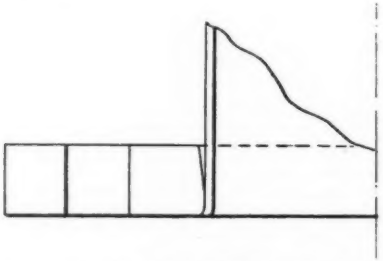


FIG. 1.—FORM OF FLANGE SUGGESTED FOR SECURING MORE EFFECTIVE METHOD OF BRAZING.

The brazing of big copper bends is not a process which can be carried through with the precision of a mechanical operation. The presence of the human element interferes with this, and opinions differ greatly in the same shop as to the exact methods to be observed so as to ensure success. The "gassing" or "burning" of the copper, which is the greatest risk it runs during the process of brazing, is a thing hardly to be comprehended by an ordinary working coppersmith. It is always "bad copper" in which hair-line cracks appear after careless annealing or brazing, and to suggest that these flaws

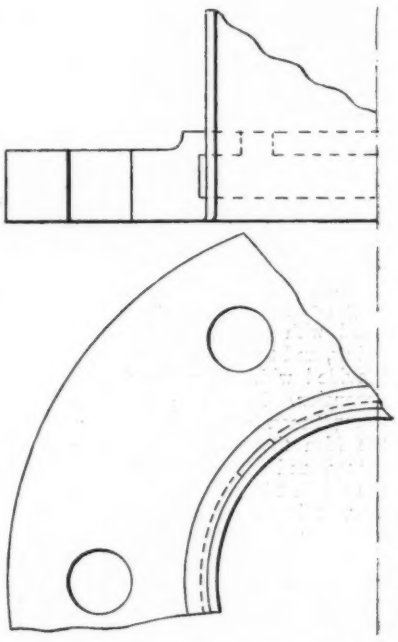


FIG. 2.—FINAL FORM ADOPTED AND PATENTED.

are due to any cause within the office of the coppersmith is to invite scorn upon one's ignorance! This risk can only be eliminated by the most careful supervision and by constant preaching to the men that "excess of air-blast" in the brazing-hearth is the only safe way to keep copper ductile.

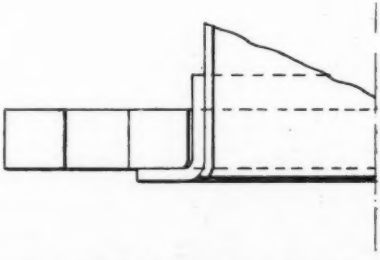


FIG. 3.—METHOD OF BRAZING SMALL COLLARS TO COPPER PIPES.

Add to the risks of manufacture, all of which may, however, be avoided by good and competent workmanship, the new discovery of which mention has been made, that the solder in the seams of copper pipes is liable to disintegration by electrolysis, and it must be admitted that the brazed copper bend has fallen on evil times. But it should not be discredited because of the few failures that have taken place. Other materials have their seamy side, but, judiciously applied, serve useful ends. Many structures common in engineering practice have had their vicissitudes, and have been perfected through failure. Good and reliable brazed pipes can be made satisfactorily to stand even high pressures such as are now being commonly employed, but the care required to produce really sound and reliable work of this kind demands that good prices should be paid for it, and that one potent factor in the production of bad or indifferent work—"cut prices"—should be discouraged where such important interests are at stake.

However, of the two—brazed or seamless pipes—wherever the latter can be used, even by departing from the ancient shibboleths of design, descended from low-pressure days, and regardless of a slightly enhanced cost, there should be no hesitation in deciding in their favour.

For the attachment of flanges to copper steam pipes, the method usually followed is that of brazing the pipe into a flange provided with a plain cylindrical bore. This, though often efficient, is not uniformly so. If the pipe when being fitted is fastened too tightly into the flange, or if the surfaces of both flange and pipe are not quite free from dirt, grease, or oxide, the solder will not strike through, and the dangerous result is produced of a joint apparently well brazed at the back, and standing quite well the hydraulic test, but in fact only brazed through a small portion of its depth and liable to be pulled off under very slight strain.

In replying to the discussion which followed the reading of his paper, Mr. Milton described some types of brazed joints upon which he had experimented, and in which special means had been adopted to ensure that the solder ran right through to the face of the flange in brazing. It is curious that the first of these is exactly similar in design to what was suggested and tried some six years ago by the writer's firm to meet the need for a

BETTER METHOD THAN THE ORDINARY ONE

of securing heavy wrought iron flanges to the receiver pipes in compound locomotives. The conditions were very severe; the pressures were not great, but the vibration the pipes had to stand was the cause of constant trouble. Then the brazing of steel or iron flanges on to copper pipes is not an easy thing to accomplish if the former are simply bored out parallel, the chief reason for this being that the expansion of the copper being so much greater than that of the steel, on heating up in the fire the pipe expands so tightly into the flange as to prevent the flowing down of the solder.

After several breakdowns abroad of the compound locomotives alluded to, a demand was made that some more certain way of brazing on the flanges should be adopted. The writer's firm then suggested the form of flange shown in the sketch, fig. 1. After numerous experiments this was not found quite satisfactory all round, though as to the striking through of the solder there was nothing left to be desired But with the large, heavy flanges then being dealt with it was found that, with only so small a parallel portion of the bore to fasten to, the flanges frequently fell off into the fire. This led to further trials, and the final adoption of the form shown in fig. 2, which was subsequently patented. The flange in this case, it will be seen, is recessed, leaving a plain narrow band top and bottom, to which the pipe is fastened. Several small ducts are then cut into the groove, from the top side, down which the solder runs into the recess. This ensures that the solder gets well down the flange, and in numerous experiments that have been made it has been found impossible to draw off the flange without tearing away a portion of the copper pipe with it.

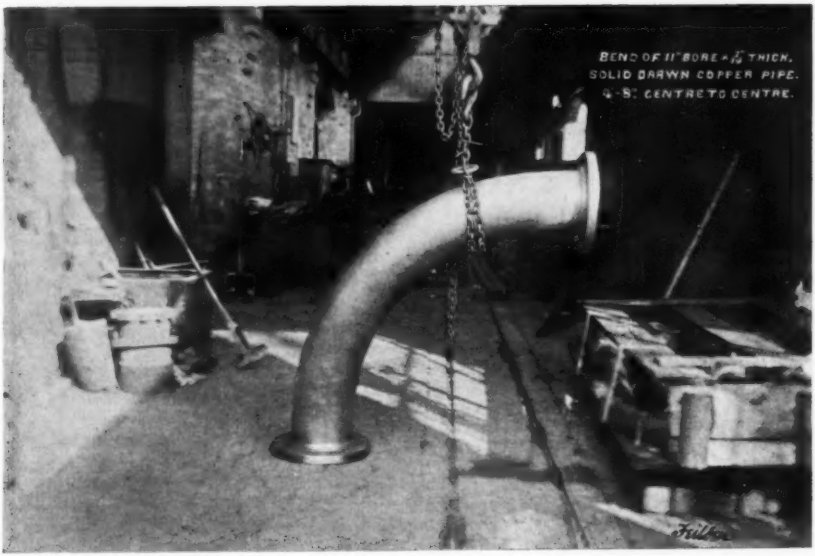


FIG. 4.—SHOWING WHAT CAN BE DONE WITH SOLID DRAWN COPPER PIPES FOR HIGH PRESSURE BENDS.

Many thousands of these brazed joints have been made without a single case of failure, and the method is

WORTHY THE ATTENTION OF ENGINEERS,

as it enables flanges with deep collars, offering considerably extra strength where failure most frequently occurs, to be brazed on to the copper pipes with certainty. It also makes it a quite simple thing to use flanges of iron or steel instead of brazing metal (commonly, but erroneously, called "brass"), which is too soft and easily deformed to be very satisfactory for making high pressure steam joints.

Some engineers specify that flanges shall be screwed and brazed on, but this is not good practice when using copper pipes. If the threads are a good fit the brazing solder will not strike in, and even with slackly fitting threads, it is open to doubt whether the brazing will penetrate far enough to be of any practical use. But the greatest fault is that the screwing of the copper pipes weakens them at the root of the flange, just the place where fracture so often occurs; if, after screwing, the metal at this point is sufficiently strong to be safe, then the whole of the rest of the pipe must be unduly heavy.

Others, again, turn off a small flange or collar from the pipe itself and use a steel or iron loose backing flange for pulling up the joints, and there is in existence a patent system of thickening up the ends of copper pipes so as to compensate for the thinning which takes place in throwing off this collar. This is a good enough method for straight runs of pipe, but offers some difficulty in fitting up making-up lengths, bends and so forth in awkward positions. The method of brazing small collars on to copper pipes as in fig. 3, and using loose backing flanges offers no advantages, from the point of view of security, over a plain brazed flange of ordinary type.

Another special type of flange, having the object of strengthening the pipe immediately behind the flange, has a number of ears cast on the back instead of the customary collar. But these are

obviously not so good as a complete collar of equal depth, provided only one can ensure a perfect braze.

Enough has probably been said to show that engineers need have no anxiety as to the possibility of obtaining strong flanges satisfactorily attached to copper pipes, a point which has exercised their minds in no small degree for some time past.

A VERY IMPORTANT POINT IN DESIGNING

pipe-ranges, the radius to be allowed for the copper bends, has already been alluded to. It has been generally recognised that the thinning of the back of the pipe in bending is a source of danger, and it has been counteracted in some cases by specifying extra gauges for the material of the bends, by using copper strips of tapering section, that is to say, thickened up where the back of the bend will come in brazed pipes, by wrapping with wire and so on. The need of great care in connection with this point really exists, for the reduction in thickness at the back of large diameter bent pipes is very considerable, and greater, indeed, than is generally imagined. The safest way is to avoid running risk by having easy bends in all cases, and a good rule to which to work is to fix the minimum radius to the centre of the pipe at three times the bore for 8-inch or smaller and four times the bore for larger sizes. If this is done, solid drawn copper pipes can be used in nearly all cases where at the present time brazed pipes are considered necessary. It is also no disadvantage to the flow of steam through the pipes that sharp bends should give place to easy ones.

Fig. 4, which is taken from the photograph of a large copper pipe, shows what can be done in the way of utilising such copper pipes for high pressure bends, and it is safe to assert that such pipes can be used with equal freedom from dangerous consequences as can steel or iron pipes.

The question of providing in an efficient manner for

THE EXPANSION AND CONTRACTION OF BOILERS AND STEAM PIPE RANGES

is one of prime importance. What is very often lost sight of is the necessity of firmly

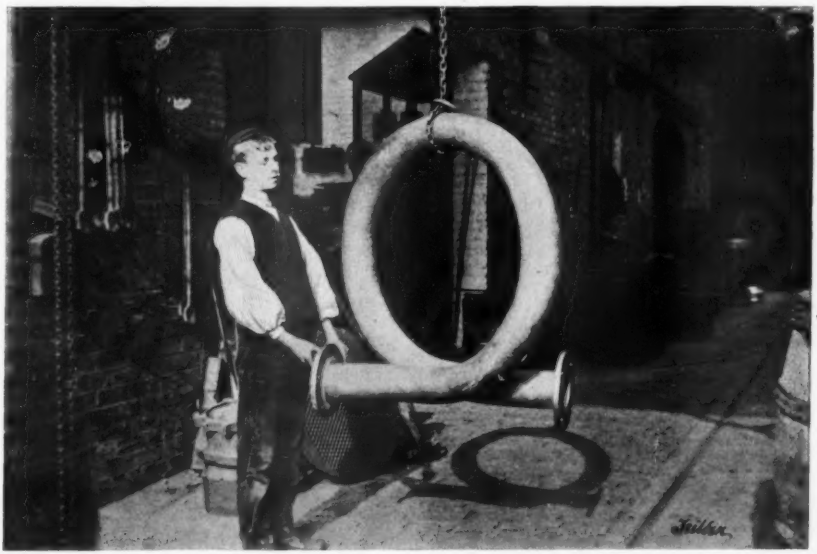


FIG. 5.—FORM OF EXPANSION PIPE RECOMMENDED FOR SITUATIONS IN WHICH THERE IS MUCH VIBRATION.

anchoring one end of the pipe range or one end of each section in a system having several expansion joints. In the latter case, if this precaution is omitted, all the expansion will probably be taken up by the joint which happens to be the most flexible, leading, in the case of copper joints of the "bellows" pattern particularly, to dangerous distortion and strain.

Of the types of expansion joints available perhaps for large sizes the most convenient is the one with sliding sleeve and packed gland. It occupies less space than any other form, but is costly and capacity for taking up expansion is almost unlimited, while it is superior to every other form for situations where there is much vibration or jar, such, for instance, as in connection with steam hammers, where endless trouble is experienced with steam pipes that are at all rigid.

Another favourite form of expansion pipe is shewn in Fig. 6. This is not so good, however, as the one previously mentioned, as, in order to bring it into reasonable dimensions, it is necessary to bend the pipes to much smaller radii, reducing the strength at the back of the

FIG. 6.—ANOTHER FORM OF EXPANSION PIPE BENT TO SMALLER RADII.

must cause a great deal of work for the engine-room staff. To work freely, too, it must be very carefully lined up in fixing, and the expansion it has to take up must all be in the direction of its length. None of these difficulties apply to well-made copper expansion-pipes or joints, which have the advantage, further, of taking up strains due to vibration. The form of expansion pipe most highly to be recommended is that shown in fig. 5. Its bend just where it is most needed to resist the strain.

Other forms of joints are shewn in Figs. 7 and 8. These are all excellent in their way, but have none of them the flexibility of the foregoing types. It is not generally known that both the bellows and U section patterns in Fig. 7 can now be obtained without seam, within certain limits of sizes, a fact which removes one of the most serious objections

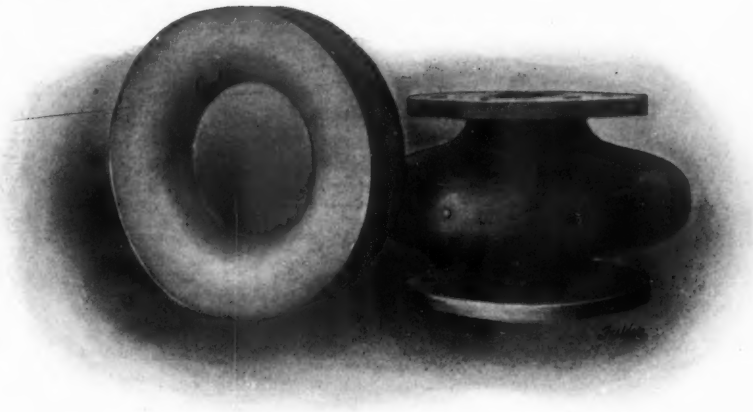


FIG. 7.—U SECTION AND BELLOWS PATTERN OF SEAMLESS JOINTS.

to their use in the minds of many engineers.

THE QUESTION OF DRAINAGE OF STEAM PIPES,

and the disastrous consequences which may follow neglect to keep them free from the water of condensation, is a point very prudently made much of in Mr. Milton's paper already referred to. It is the misfortune, rather than the fault of copper pipes, that they have been so frequently the victims of water-hammer. Where they are inserted in ranges of iron or steel steam pipes they are generally used for the bends, and so receive the full impact of the plug of water impelled in front of the entering steam. No engineer thinks of putting in copper bends of relatively the same strength as the other portions of the range of pipes, so

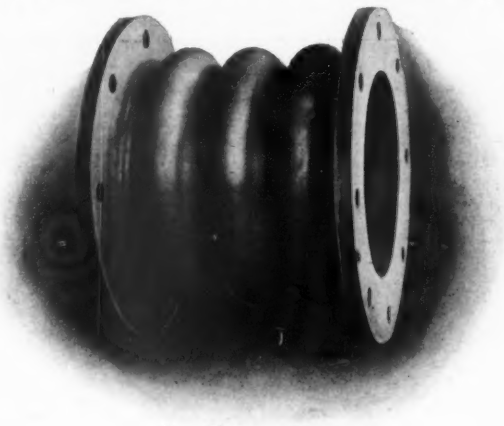


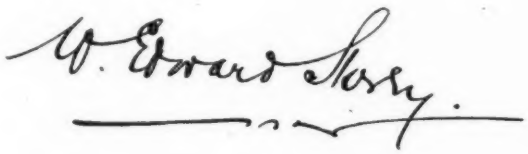
FIG. 8.—ANOTHER FORM OF JOINT.

that, naturally, they are the first to give way, being the weakest units and having to bear the heaviest stresses. But it does not follow that abandoning copper bends in favour of iron or steel, and still continuing to neglect the proper drainage of the pipes, engineers will be free from accident; on the contrary, accidents will probably be much more severe in their results, and will take place in parts far more difficult to repair.

It is to be presumed that, if reasonable safety can be assured in its use, engineers will prefer to use copper for steam pipes because of its undoubted convenience. The difficulty of providing for bends in steel, the expense of such bends, the length of time required in their manufacture, the difficulty in large sizes of securing the flanges by screwing, and, perhaps more important, the trouble of fitting making-up lengths, which cannot be done until boilers, engines, and steam pipes are all erected, and which often have to be set so as to compensate for all errors both in dimension and line, these and others are all germane to steel and iron pipes. The copper pipe, on the other hand, can be fitted and completed in a very short time, and much vexatious and costly delay thereby avoided. In the matter of speedy repairs, we have the experience of one of the superintending engineers of a large line of daily passenger steamers that copper holds the field to the exclusion of all rivals.

As to comparative cost, it is impossible to make a really reliable statement, as every case presents different circumstances for consideration. Perhaps copper is dearer than lap-welded wrought-iron, it can hardly be dearer than weldless steel, and it is not to be supposed that welded steel pipes will be looked upon with much favour after the disastrous accident to the boiler tubes of the "Terrible." But, even if the first cost in all cases is higher for copper, the owner has a valuable asset in this material which he has not with any other, and this should be taken into consideration.

It will be seen that the foregoing is not a defence of copper through thick and thin, as who would say, "Our country, right or wrong!" It is merely an attempt to show that, even in these days of high steam pressures, copper is a metal which, when used with discretion, involves the user in no undue risk, and which may, the adverse criticisms which have been passed upon it notwithstanding, still have a useful future before it in the hands of the mechanical engineer as a suitable material for the manufacture of steam pipes.



The Building of a Great Railway.

The Great Central Extension to London.

❀ ❀ ❀

WE shall offer no apology for publishing a history of the Great Central Railway Extension to London, in spite of the fact that the press throughout the country, both from technical and popular standpoints, have largely, and in a more or less detailed manner, described this great undertaking. An industrial Magazine, with such pretensions to thoroughness in scope and treatment as are claimed for this publication, and whose appearance is practically contemporaneous with the completion and opening of the railway under consideration, would be falling short of its policy and programme in neglecting to record and describe the features in the history and construction of one of the greatest engineering achievements of the latter end of the century.

But our justification will not be merely on this account. We shall claim for this particular series of articles a completeness and authenticity both in respect of the line itself and of the machinery used in conjunction therewith, which will render it an altogether exceptional compilation. The Editors have received in the construction of the articles the unstinted services of all those prominently identified with the line, and no more fitting opportunity will occur than here to at once express our deepest obligations and thanks to

SIR DOUGLAS FOX, MR. EDWARD PARRY, M.I.C.E.,
SIR WILLIAM POLLITT, MR. J. ROSTERN, MR. HARRY POLLITT,

and the Resident Engineers all over the system, the several contractors, and others, for the courtesy shown and the special assistance rendered to us.

The articles will be sectionised and run through six or seven issues, the initial instalment dealing with the first contract, commencing at Annesley, and so on, until the London terminus is reached.

Special machinery and plant will be noticed where possible at such points where it has been installed, and the series will be concluded with an article assigned to the locomotive and rolling stock departments, including a description of the signalling and running arrangements.

The whole will be lavishly illustrated from photographs and working drawings, and the descriptive matter so treated as to appeal to the practical engineer and lay reader alike.

❀ ❀ ❀

A CELEBRATED American *savant* in wishing to express his high appreciation of a certain set of volumes, those issued by Bohn to wit, could convey no higher compliment to the publisher than by stating that they were for the literary man what railways were to civilisation. The opening up and development of the means for the rapid and cheap transit of persons and merchandise has been one of the most important factors in the industrial progress of the world. Glancing cursorily at the map of England, one would have thought that the network of railways which already compassed this country like the web of a spider, amply sufficed for all requirements, but a more detailed examination would show that until the tenth, and possibly the last, great trunk line had been completed, connecting the metropolis with Midland coalfields and manufacturing districts, a large district comparatively close to London was not adequately provided with railway accommodation, and that farmers and traders of all descriptions along the new line encountered serious difficulties in the transportation of their wares to the largest market in the world, and that as a necessary consequence they had to content themselves with the lower values hitherto only obtainable in country towns. As affecting the Metropolis, the residents of London may owe to the Great Central Railway a slight diminution in the cost of coal in the near future, inasmuch as the new system taps in a more direct manner than any of the older main

GREAT CENTRAL
RAILWAY.
EXTENSION TO
LONDON.
REFERENCE
Great Central Railway
Great Central Railway Extension to London
Running Powers from Quainton Road to London
LEEDS
HULL
GRIMSBY
DONCASTER
SHEFFIELD
MANCHESTER
LIVERPOOL
NOTTINGHAM
DERBY
LEICESTER
LOUGHBORO'
BIRMINGHAM
RUGBY
AYLESBURY
QUAINTON RD. JUNCTION

lines, some of the best coal districts of Yorkshire. The reasons enumerated amply suffice to demonstrate

THE GENUINE NECESSITY OF THE LINE,

hence it will not exhibit undue over-confidence to anticipate that an equivalent amount of commercial success will attend the enterprise.

The Great Central Railway is a title which not only covers the new extension to London, but the older and popular Manchester, Sheffield, & Lincolnshire Railway, which has been in existence since the 1st of August, 1846.

The original progenitor, however, of the system which now ramifies over such an important area of the country, was the Sheffield, Ashton-under-Lyne, and Manchester Railway, dating as far back as 1837, which was subsequently incorporated in succession with the Sheffield & Lincolnshire Junction Railway, the Sheffield & Lincolnshire Extension Railway, the Great Grimsby & Sheffield Junction Railway, and the Grimsby Docks Company. The total system at that time (1845) extended from Manchester to Grimsby, and including branches, consisted of about 157 miles.

FACSIMILE OF THE FIRST TICKET ISSUED FROM NOTTINGHAM TO LONDON.

Within twenty-five years of its incorporation, the Company had acquired by amalgamation, purchase, or lease, or had secured a part ownership of the following lines, amounting in all to 187 miles:—

Manchester, South Junction and Altrincham (jointly with the London & North-Western).

South Yorkshire.

Cheshire lines (jointly with the Great Northern and Midland).

Marple, New Mills & Hayfield (jointly with the Midland).

	1871.	1881.	1891.	1898.
Capital created	£14,783,533	£26,175,711	£31,813,294	£40,665,030
Lines owned	179 miles	270 miles	300 miles	453 miles
Lines partly owned	215 ,,	215 ,,	205 ,,	223 ,,
Foreign lines worked over	88 ,,	113 ,,	157 ,,	210 ,,
Canals and tramways owned	175 ,,	175 ,,	175 ,,	112 ,,
	No.	No.	No.	No.
Engines owned	280	461	655	864
Coaching stock owned	551	727	1,028	1,281
Goods and mineral stock owned	7,837	12,056	15,092	24,442

It will be seen, therefore, how a comparatively isolated link of railway became, by gradual accretions, a trunk line of great importance, involving a scheme of railways which brought into connection some of the

MOST IMPORTANT MANUFACTURING TOWNS OF THE KINGDOM,

ramifying to the eastward through a country of remarkable fertility, and culminating at the eastern extremity in a port within the mouth of the Humber, which in the rapidity of its extensive commercial growth has been almost without parallel.

West Riding & Grimsby (jointly with the Great Northern).

Manchester & Stockport (jointly with the Midland and Cheshire lines).

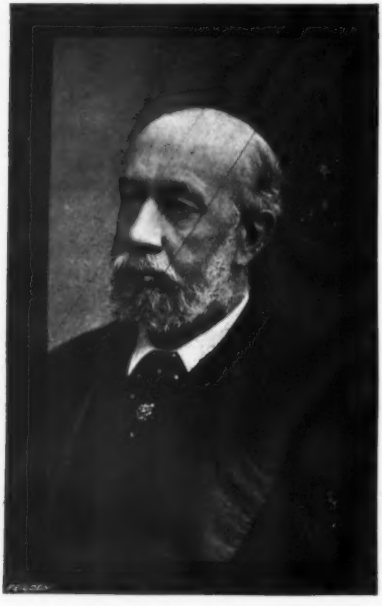
Macclesfield, Bollington & Marple (jointly with the North Staffordshire).

Oldham, Ashton & Guide Bridge (jointly with the London & North-Western).

Trent, Ancholme & Grimsby.

The development since 1871 cannot be better shown than by the above table.

The points of access of the Company's system before the construction of the trunk line to London, to briefly recapitulate, were from the largest Docks in the North of England on the one hand, viz., Liverpool, and on the other those at Hull, passing *en route* such important industrial centres as Warrington, Manchester, Oldham, Ashton, Stockport, Stalybridge, Penistone, Barnsley, Sheffield,



THE RT. HON. THE EARL OF WHARNCLIFFE, LATE CHAIRMAN OF THE COMPANY. DIED MAY 13TH, 1899.

Lincoln and Grimsby, having an additional termination in the Company's own extensive Docks at the latter point. On these Docks, it may be observed, the Company have spent about £2,500,000, the area of the estate being 443¼ acres, 103¼ of which are water. In short it may be said that the trade of the Town depends upon these extensive Docks, and that practically

GRIMSBY OWES ITS FORMATION AND DEVELOPMENT

to the forward policy of the Company We give a general view of these, as well as an illustration of the Fish Dock.

The first attempt to improve the natural harbour was in 1801, when the old dock was opened. This dock was constructed by a private company, who afterwards sold it to the Manchester, Sheffield, & Lincolnshire Railway Company. The directors, availing themselves of the natural advantages of the port, soon increased the facilities for carrying on a large foreign trade, by the construction in succession, of the Royal Dock, 25 acres in extent and the new Alexandra and Union Docks, 49¼ acres. The Fish and Graving Docks bring up the total area to 103¼ acres.

Four drops have been provided by which coal can be shipped at the rate of 200 tons per hour at a single point, and eight vessels can load at one time.

A special feature is the Hydraulic Tower, which we illustrate. This tower is 300 feet high, and 1,000,000 bricks were used in its construction. It is 28 feet square at the base, and contains a tank holding 26,500 gallons of water for working the hydraulic machinery. The column of water exerts a pressure on the cylinders of 100 lbs. per square inch.

The traffic to the Continent has been established by means of a fleet of thirteen steamers of modern construction, extensively engaged in trade and passenger traffic with the ports of Rotterdam, Antwerp, and Hamburg. The vessels, one of which we illustrate, are of the most modern construction, the saloons being fitted with every convenience to ensure the comfort of passengers. Most of them are fitted throughout with the electric light.

Special goods and passenger trains are run in connection with the steamers to and from all parts of the Company's system.

The total weight of coal exported during the year 1898 from Grimsby exceeded that of the year 1887 by 1,061,727 tons, while the total value of goods exported was £10,302,514 as against £8,180,750 in 1887.

In the distribution of fish, this railway stands second to none, having despatched

THE DIRECTORS OF THE GREAT CENTRAL RAILWAY, JULY, 1899.

1. ALEXANDER HENDERSON, ESQ., M.P.; 2. THE RT. HON. CHAS. B. STUART-WORTLEY, Q.C., M.P.; 3. THE RT. HON. VISCOUNT CROSS, G.C.B., G.C.S.I.; 4. FREDERIC SMITTON, ESQ.; 5. SIR EDWARD WATKIN, BART.; 6. A. M. WATKIN, ESQ.; 7. COLONEL CHAS. F. SURTEES; 8. SIR JOHN MACLURE, BART.; 9. EDWARD CHAPMAN, ESQ.; 10. CLEMENT M. ROYDS, ESQ., M.P.; 11. GEORGE Y. HUTTON, ESQ., C.B.

during the last year over 103,771 tons to all parts of the country.

Not the least important factor in the carrying trade of the Company is the coal traffic. For instance, the total output of railway-borne coal from the South Yorkshire collieries was in the year 1891 4,706,415 tons, while the tonnage in the same year from the main line collieries was 1,751,756 tons, thus bringing the grand total up to 6,458,171 tons. It is in connection with the coal traffic that the despatching empty wagons to their respective owners has to be arranged.

Considerable expense, therefore, is involved in laying down sidings and in the actual operation of shunting, the most profitable part of the journey being the long runs after the train has been made up, and which the Manchester, Sheffield and Lincolnshire Railway were not able to take advantage of by the fact of their system having no outlet to the South. Hence they were under the necessity of

LONDON ROAD STATION, MANCHESTER. (EXTERIOR.)

ORIGINAL PROJECTION OF THE SCHEME FOR CONTINUING THE LINE TO LONDON

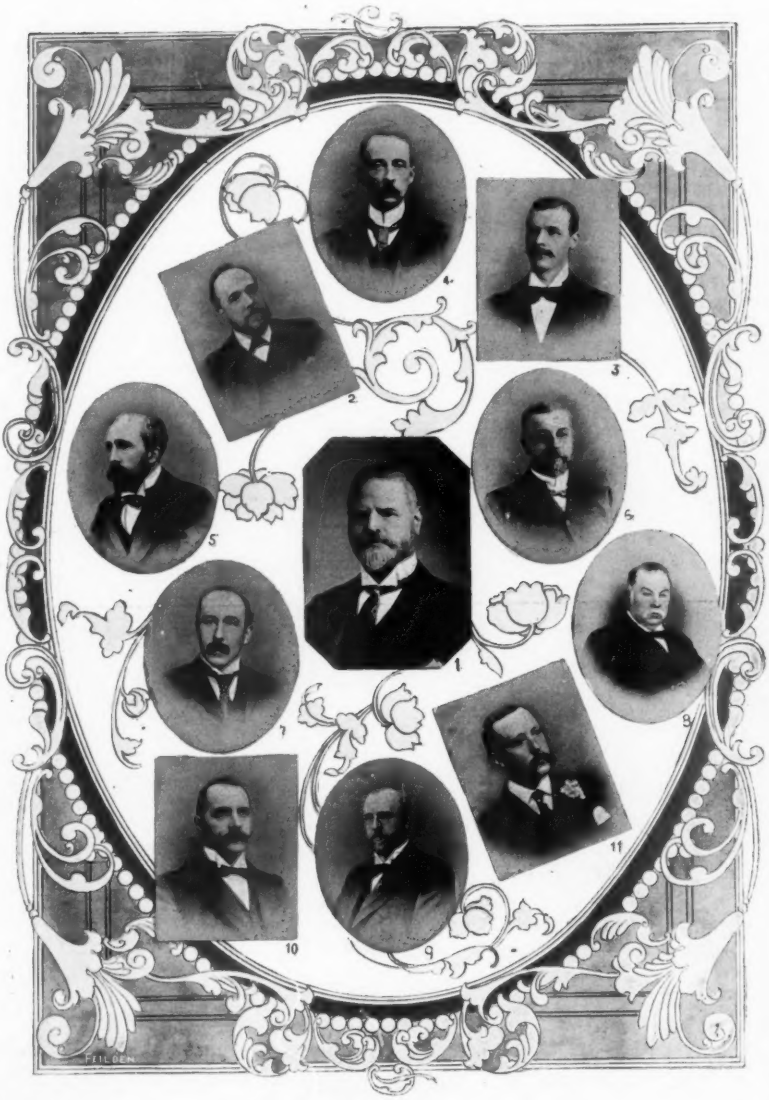
is to be sought, as, of the enormous total mentioned above, the greater bulk of the coal had to be passed over to other companies' systems after having received only a small share of the through rate.

As may be imagined, the most expensive portion of coal traffic working is in the immediate vicinity of the collieries, where the process of loading, sorting, and forming the wagons into trains, and

HANDING THIS PROFITABLE PART OF THE WORKING OVER TO OTHER COMPANIES

before they had carried for any distance, and this meant that the share of the profits that fell to the Great Central Railway Company amounted in the aggregate to only about one third of the total. Hence it is no matter for surprise that the means of securing direct communication with the South by a route which should pass through as many important industrial centres as possible was a question that called for earnest con-

OFFICERS OF THE GREAT CENTRAL RAILWAY.

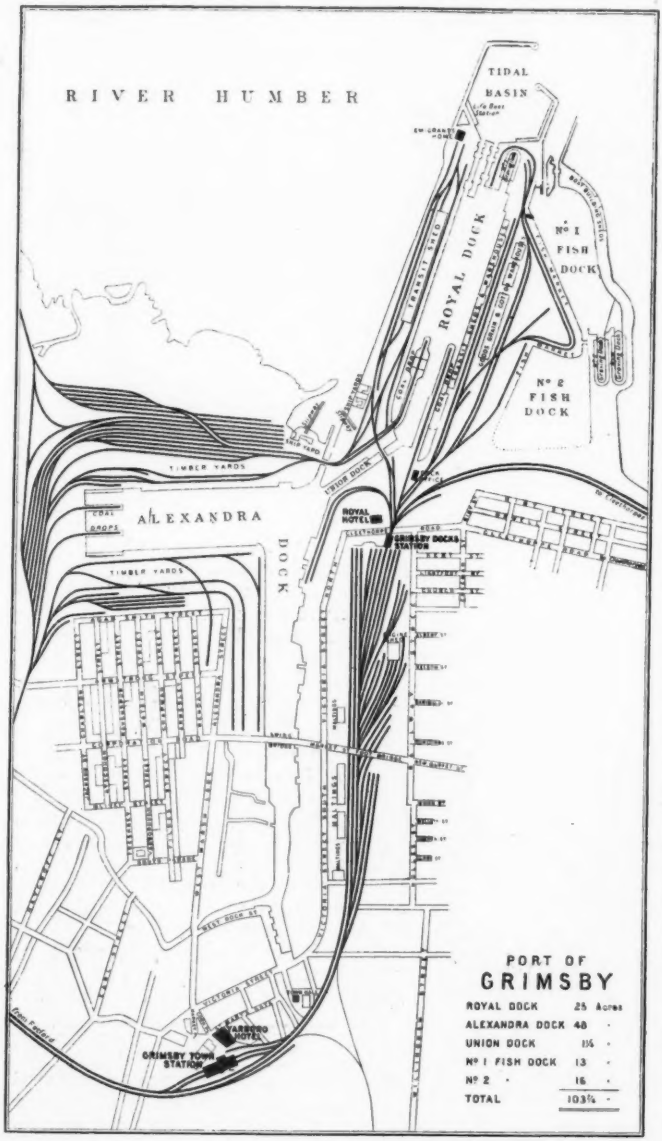


1. SIR WM. POLLITT, GENERAL MANAGER; 2. C. T. SMITH, ESQ., GOODS MANAGER; 3. HARRY POLLITT, ESQ., LOCOMOTIVE ENGINEER; 4. C. A. ROWLANDSON, ESQ. ENGINEER; 5. R. HAIG BROWN, ESQ., SUPERINTENDENT OF LINE; 6. OLIVER HOLT, ESQ., SECRETARY; 7. EDWARD WATKIN, ESQ., MINERAL MANAGER; 8. R. LINGARD MONK, ESQ., SOLICITOR; 9. F. WILLIAMS, ESQ., ACCOUNTANT; 10. J. KOSTERN, ESQ., ASSISTANT GENERAL MANAGER; 11. THOS. PARKER, JUN., ESQ., CARRIAGE AND WAGON SUPERINTENDENT.

LONDON ROAD STATION, MANCHESTER. (INTERIOR.)

VICTORIA STATION, SHEFFIELD. (INTERIOR.)

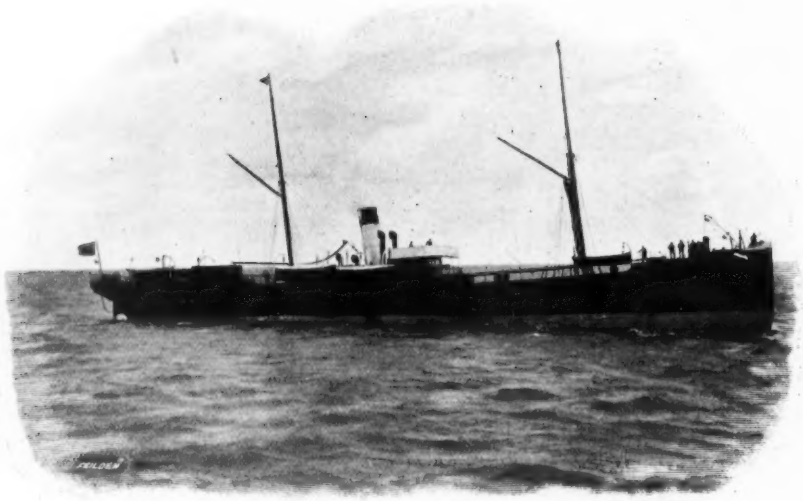
sideration, not only for the reason that the Company would then be able to take advantage to the full of the profit of the carrying trade to the South, but to provide additional facilities to relieve the overcrowded state of the already existing lines.



As far back as the year 1873 the idea of establishing independent communication with the Metropolis was conceived, and a scheme was formulated, having for its object the construction of joint lines with the Midland Railway, terminating at a spot now occupied by St. Pancras Station, but had to be abandoned on account of the vigorous opposition offered by the Great Northern Company.

In spite of this rebuff the scheme was not allowed to drop, and fifteen years later the Great Central Company made an effort to obtain a concession for the construction of a line south as far as Chesterfield, but their efforts were neutralised on this occasion by the effective opposition of the Midland Railway.

In the following Session a fresh and still more comprehensive scheme was formulated and



ONE OF THE GREAT CENTRAL RAILWAY COMPANY'S FLEET, THE S.S. "LINCOLN."

deposited in the shape of a Bill, viz., a line from Beighton, through Staveley and Chesterfield, down to Annesley, the latter about nine miles north of Nottingham, there to form a junction with the Great Northern Railway's system. After further opposition and lengthy delays the desired powers were obtained, and

HYDRAULIC TOWER, GRIMSBY.

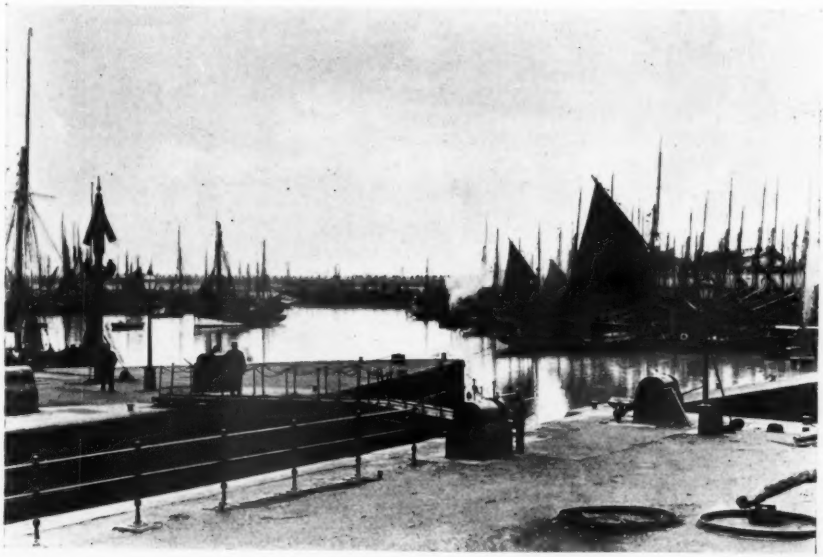
that portion of the line south became a *fait accompli* in 1892.

To connect Annesley with the Metropolis it was proposed to construct a line from the former place to Quainton Road, a distance of 92 miles, there to form a junction with the Metropolitan Railway, and to construct a large terminus in the Metropolis near to Lord's Cricket Ground. A Bill to this effect was presented to Parliament in the Session of 1891. In view of the strenuous opposition previously encountered, it hardly came as a surprise that after a fierce struggle before a Committee the Bill was thrown out. Nevertheless, the interval before the Session of 1892 was not wasted, and the scheme was amended in several directions before being re-presented. An important advantage had been gained in the interim by an

AGREEMENT EFFECTED WITH THE GREAT NORTHERN RAILWAY,

by which effective opposition was removed from that quarter as to mutual advantages in respect of running powers, through rates

BIRDSEYE VIEW OF ROYAL DOCK, GRIMSBY, TAKEN FROM THE HYDRAULIC TOWER.



VIEW OF THE FISH DOCK, GRIMSBY.

MR. EDWARD FARRY, M.I.C.E.,
The Engineer of the Northern Section.

traffic, and station accommodation, all of which meant increased facilities to the public.

Further difficulties in the shape of objections by the owners of freehold property in the Metropolis were overcome, and the amended Bill was deposited, strongly supported by many of the largest Midland towns as well as by numerous Local Boards, Chambers of Commerce, and other public bodies. On April 12th, 1892,

THE BILL WAS PASSED BY A COMMITTEE OF THE HOUSE OF COMMONS,

and subsequently by the House of Lords, although, owing to the dissolution of Parliament which took place, the Royal assent was not obtained until the end of March, 1893.

By this Act the Great Central Company were empowered to construct 94 miles of railway, which, added to the 42 miles of the Metropolitan system over which running powers had been simultaneously obtained, practically added 136 miles of through main line to the mileage of 886 already owned or worked over.

Seldom, if ever, in the history of railway enterprise has a scheme encountered so much opposition, and not the least factor in bringing to a successful issue the Parliamentary and other negotiations was the indomitable efforts of the man to whom the whole scheme owed its inception, viz.,

SIR EDWARD WATKIN, BART.,

the then chairman, not only of the Great Central Railway Company but also of the South Eastern and Metropolitan Companies.

The new line, although not shortening the distance between London and some of the more important towns which it touches, and which are already served by direct railway accommodation, will, nevertheless,

PROVIDE THE FACILITIES ATTACHING TO ALTERNATE ROUTES;

while, to towns of secondary importance, it will bring the advantages attendant upon being situated on a main trunk line. Generally speaking, the transport of produce and manufactures to London from the great coal-fields in Yorkshire and Nottinghamshire, the textile and other manufacturing districts in the neighbourhood of Manchester and Liverpool,

MR. A. A. BARKER,
Resident Engineer of No. 1 Contract.

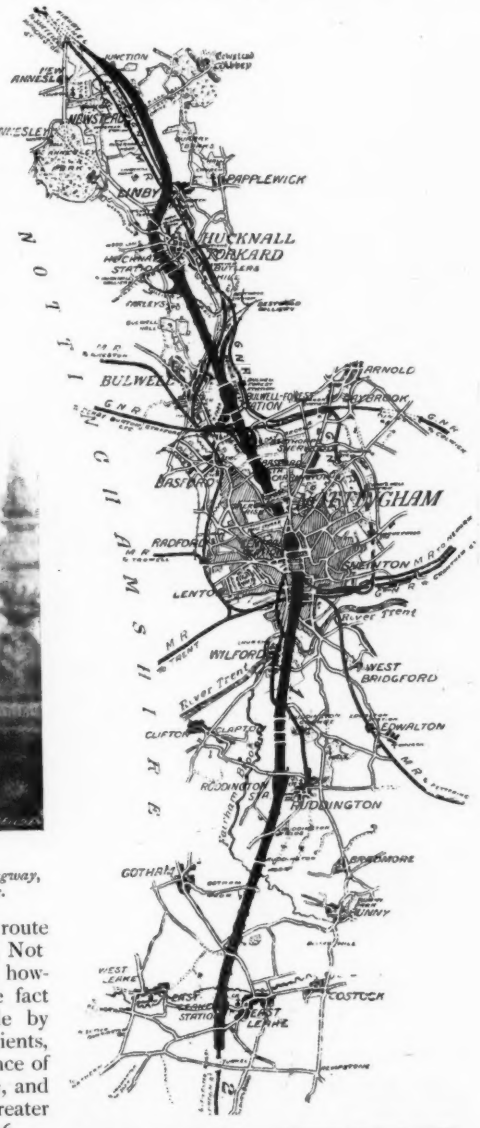
the iron and steel centres of the Midland towns, the agricultural districts of Lincolnshire, the stone-quarry districts of Leicestershire, will be greatly improved, not to say revolutionised.

Nottingham and district will reap special advantages, as the line will bring into communication with the town many desirable residential places which have hitherto been unprovided with railway communication, besides conferring upon the inhabitants the desideratum of a central station in the very heart of the town.

J. W. LOGAN, ESQ., M.P.,
Senior Partner in the firm of Logan & Hemingway, Contractors for the first section of the line.

The augmented distances by this route to Rugby, Loughborough, Leicester, Nottingham, Sheffield, and Manchester, however, will be compensated for by the fact that quick running will be possible by reason of the flat curves and easy gradients, as, with two exceptions, one a distance of ten miles with a gradient of 1 in 132, and a very short section of 1 in 100, no greater rise will be encountered than 1 in 176.

Taking, as a comparison, the magnificent runs now being made by the Northern of France Railway between Paris and



MAP OF CONTRACT NO. I.—ANNESLEY TO EAST LEAKE.

CHAS. R. HEMINGWAY, ESQ., AND MR. FREDK. COLLINS,
Partner and Manager respectively of Messrs. Logan & Hemingway.

Calais, there is ample indication that improved times are called for and are possible between London and Manchester, and, in view of the excellence of the line itself and rolling stock, there is a fine field for the Great Central Company to hold its own, if not actually to beat its more formidable competitors in matters of speed and punctuality. Every advantage has been taken of the increased knowledge which has been acquired in the construction of railways during the last twenty-five years or more, that is, since the completion of the last great trunk line into London, with the result that, for well-drained and well-ballasted cuttings and embankments, the new line of the Great Central Railway Company should prove one offering the

BEST CONDITIONS FOR EASY AND FAST RUNNING INTO LONDON.]

In possession of such unique advantages, the Company needed only the services and energy of an enterprising genius to develop all the possibilities that lay in this great organisation. Such a man is found in the person of

SIR WILLIAM POLLITT.

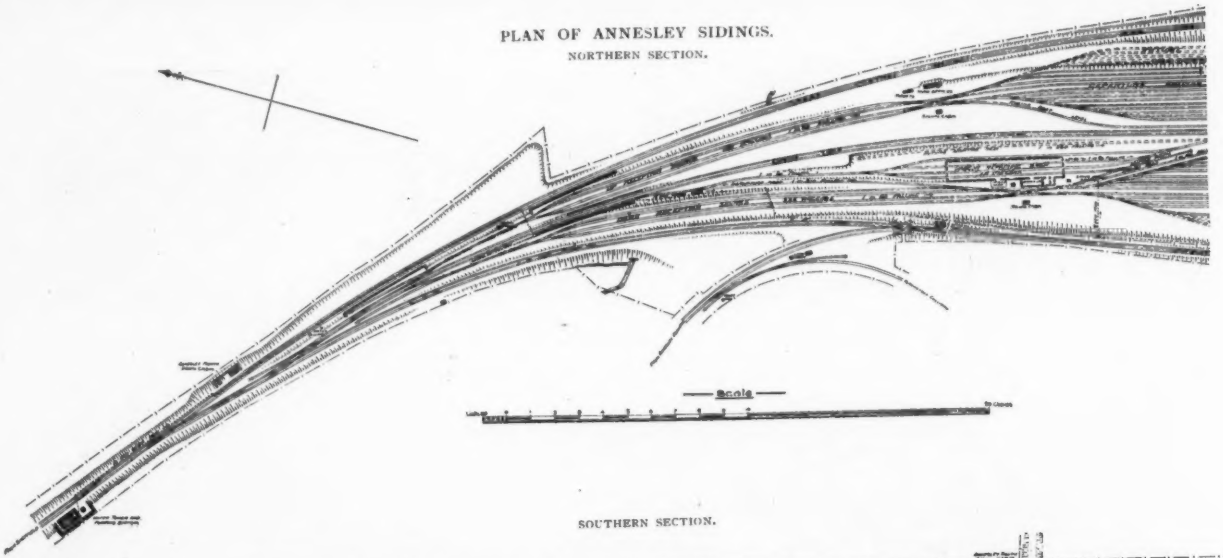
the General Manager of the line, who, with characteristic progressive qualities, has already advanced the claims of the line upon the manufacturer, merchant, agriculturist, and excursionist alike.

Sir William's railway experience extends over almost his whole working life. For forty years he has been associated with the Manchester, Sheffield, and Lincolnshire Railway; in 1869 he was appointed Accountant to the Company, relinquishing this in 1885 for the responsible and arduous position of General Manager. Sir W. Pollitt is also chairman of the Wrexham, Mold and Connahie Quay Railway, as well as a Director of the Wrexham and Ellesmere Railway Company, the North Wales and Liverpool Railway, and the Sheffield and South Yorkshire Navigation Company. He is the recipient of a silver Flaxman vase bearing an inscription which sets forth that it was "Presented to William Pollitt, General Manager of the Great Central Railway, by the twelve Directors whose names are hereto appended, not

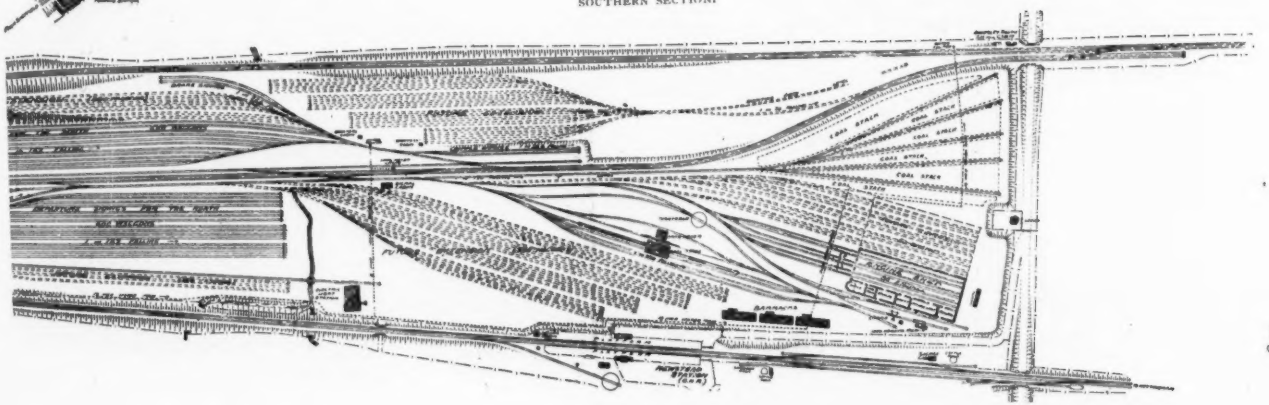
CUTTING SOUTH OF KIRKBY TUNNEL, SHEWING THE NEW SIGNAL BOX. COMMENCEMENT OF NEW LINE.

PLAN OF ANNESLEY SIDINGS.

NORTHERN SECTION.



SOUTHERN SECTION.



GENERAL VIEW OF ANNESLEY SIDINGS.

VIEW SHOWING ANNESLEY COAL DROP.

only in appreciation of his long and faithful service, but also of their strong personal feelings of regard and esteem for him."

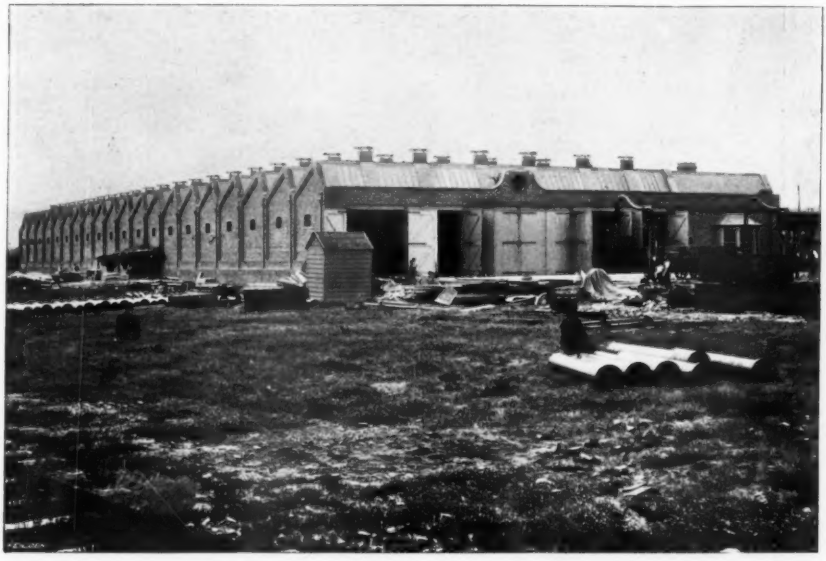
Sir W. Pollitt is ably assisted by

MR. J. ROSTERN,

the Assistant General Manager, while he is fortunate also in possessing the esteem and good-will of his staff of proved ability in their respective departments.

The contracts for the construction of the line, which had been divided into seven sections, were let in September, 1894, to the following well-known contractors:—

1.—Annesley to East Leake,
Messrs. Logan & Hemingway.
2.—East Leake to Aylestone,
Mr. Henry Lovatt.
3.—Aylestone to Rugby,
Messrs. Topham, Jones, & Railton.
4.—Rugby to Cherwelton,
Messrs. Thomas Oliver & Son.
5.—Cherwelton to Brackley,
Messrs. Walter Scott & Co.
6.—Brackley to Quainton Road,
Messrs. Walter Scott & Co.
7.—London end (Finchley Rd. to Marylebone Station),
Mr. J. T. Firbank, M.P.



ANNESLEY ENGINE SHED.

THE NORTHERN SECTION—ANNESLEY TO RUGBY.

Contracts Nos. 1–3 comprise the Northern section of the line, a distance of 52 miles, which is the one to which we shall first devote our attention. The engineer responsible for this is

MR. EDWARD PARRY, M.I.C.E.

He was born in North Wales, and during the term of his articles was employed on some Welsh railways; later, joining the staff of the Midland Railway Company as assistant engineer, and was appointed, when the Midland commenced the line from Nottingham to Melton, as resident engineer for the northern portion, between Nottingham and Upper Broughton. This entailed some heavy engineering work, including the bridge over the river Trent at Nottingham, the Stanton tunnel, and many other important details. For ten years he

BRIDGE OVER NEWSTEAD ABBEY DRIVE.

BRIDGE OVER MIDLAND RAILWAY AT LINBY (NOTTINGHAM AND MANSFIELD BRANCH)

OVER THE GREAT NORTHERN RAILWAY, LINBY.
(LEEN VALLEY BRANCH.)

held the highly responsible position of County Surveyor of Nottingham, and after his retirement from that post was again engaged upon railway work of varied character. In conjunction with the late Mr. Charles Liddell, he laid out that portion of the Great Central line between Beighton Junction and Chesterfield and on to Annesley. The whole of the plans for the London extension were prepared by him for Mr. Liddell, and upon the passing of the Bill authorising the construction of the line, Mr. Parry was appointed chief engineer for the northern section. Acting immediately under Mr. Parry are Mr. F. W. Bidder, Chief Assistant, Mr. A. E. Lambert, in charge of the architectural work, and one resident engineer for each of the three sections, all of whom have had valuable experience in this country in railway engineering.

A very large staff also was controlled by Messrs. Logan and Hemingway, the contractors for the first section of the line which extends from

ANNESLEY TO EAST LEAKE.

This is one of the oldest contracting firms in connection with railway work in the United Kingdom, and portraits of the principals and manager are given. It will be remembered that the masonry of the Tubular Bridge over the Menai Straits, commenced in 1846, was carried out by the Hemingways, the grandfather and granduncle of the present bearer of the name. The senior partner, Mr. John W. Logan, M.P. for the Harborough Division of Leicestershire, is a familiar figure to residents in the hunting district, but whose work is known to a world-wide circle. Mr. F. Collins, the present manager, has been connected with the firm for upwards of fifty years, and has given active attention to the details of this contract. The ground covered in line is over twenty miles, and involved the removal of about three and a quarter million cubic yards of excavation, the building of about two hundred thousand cubic yards of brickwork, in which some seventy million bricks were used, and 1,775 yards of viaduct, the formation of 2,253 lineal yards of tunnelling, and the laying of (including sidings) seventy-five miles of single line permanent way. The resident engineer for the section is Mr. A. A. Barker, whose portrait we have much pleasure in giving.

The new line, as will be seen from the accompanying contract map, commences by a junction with the existing one of the Company near Annesley, a colliery village about nine miles north of Nottingham. On the immediate right of the extension is a large yard of exchange sidings, a view and plan of which we give. This has been arranged for the sorting of loaded wagons of coal for the south, and empty wagons of coal from the south to the north, in order that they may be the more conveniently taken to the collieries for which they are intended. This scheme of exchange, or sorting sidings, has been arranged with great care, and is equal to the present accommodation of 1,665

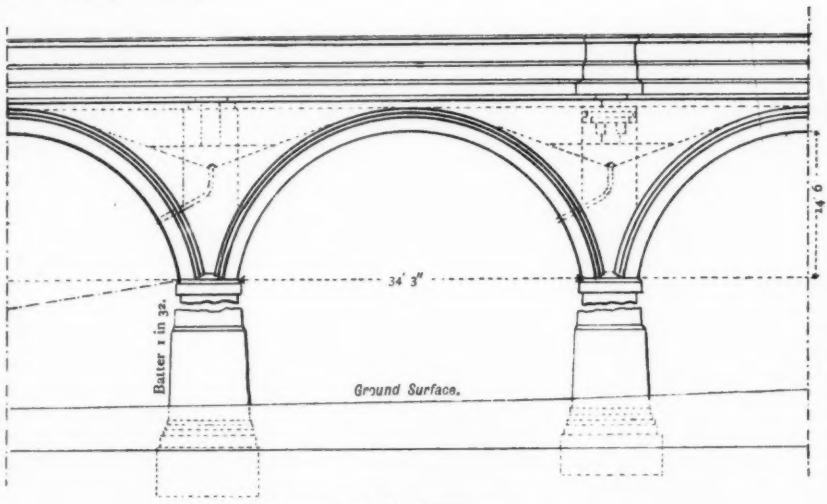
BRANCH LINE TO THE HUCKNALL COLLIERY.
LOOKING SOUTH.

wagons, with additional land for future extension, which would enable them to accommodate a further 2,040 wagons. In addition to this accommodation for wagons, the sidings that are at present laid down number something like the length of 17 miles of road. The yard is fitted up with all modern appliances, substantial electric power depôt, large wagon repairing shop, large engine shed, turntables, balancing table, coal stage, a water tower, numerous water columns, yard offices for shunters, and everything necessary to equip a large sorting depôt of so big a railway system. From this point the coal and goods trains will be run through to similar sidings at Woodford in Northamptonshire, and thence to Neasden, a suburban station in the north of London, where arrangements will be made for receiving and distributing this traffic.

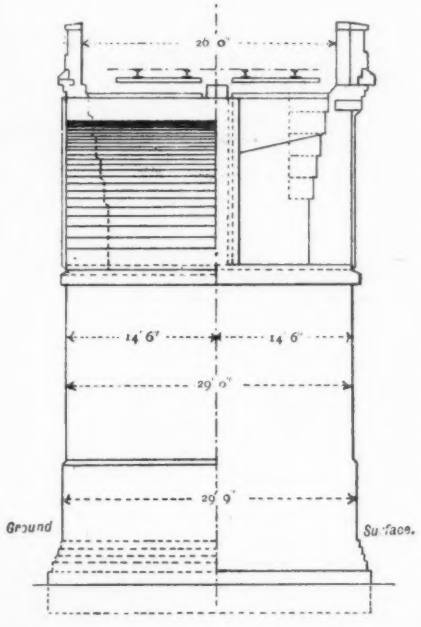
About a mile from the starting point of the first contract the line passes over a carriage drive to Newstead Abbey (at one time the residence of Lord Byron, the poet) by an ornamental bridge, the face girders of which are cast-iron arched ribs, while the intermediate girders are steel plate horizontal beams, both supported on abutments built of coursed rubble work. The ornamental and graceful design is one of the chief characteristics, as will be seen from the illustration.

Near Linby the line passes over the Midland and Great Northern Railways by three-span steel girder bridges, the lengths of each span being respectively 61 ft., 61 ft. and 23 ft. in the former case, and in the latter 47 ft., 78 ft. and 26½ ft. These bridges had to be of somewhat unusual size in order to provide for a possible widening by the respective Companies. Along the Leen valley the line runs practically parallel with the Great Northern and Midland Companies' existing lines, but at a different level, and provides accommodation for the colliery town of Hucknall Torkard, about four miles from Annesley, from which point runs a small branch to the Hucknall

BULWELL VIADUCT.



BULWELL VIADUCT.
PART ELEVATION OF ARCHES ON THE SQUARE.



BULWELL VIADUCT.
CROSS SECTION THROUGH ARCH AND PIER.

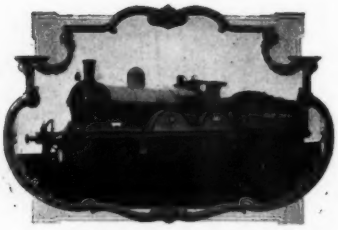
colliery. A deep cutting is passed through hereabouts, which is in magnesian limestone, and gave very considerable difficulty to the contractors in its removal. A short distance south of this point the line crosses over the Midland Railway and River Leen by a high viaduct, near which point is Bulwell Common Station and two or three junctions of branch lines constructed jointly with the Great Northern Company for the purpose of giving access to the Leen Valley and Derbyshire lines of that Company. Bulwell Viaduct, the first work practically of any considerable dimensions, is some 420 yards in length and has an average height from the ground of 44 feet, to provide a site for which a considerable pillar of coal had to be acquired. It was completed in the exceptionally short period of a little over twelve months, and six and a-half millions of bricks were used in its construction.

The arches of this viaduct are partly on square and partly on skew. Eighteen of the arches have each a span of 34 ft. 3 ins., a rise of 14 ft. 6 ins., and a depth of 2 ft. 3 ins. at the centre. The piers are 29 ft. in length, 5 ft. 3 ins. wide under the springings, 7 ft. 6 ins. at ground line, with a uniform batter of 1 in 32. The face line

is broken at every second pier by a small projection. The skew arches are 30 ft. in span on the square and 39 ft. on the skew, which is at angle of 50 deg. 10 min. The thickness, 5 ft. 3 ins. on the square, increases to 6 ft. 10 ins. on the line of the thrust of the longitudinal axis of the oblique part of the viaduct. At the haunching the depth of both square and skew arches is increased to 2 ft. 7½ inches. The materials are here brick and concrete instead of the steel lattice work which figures so largely in other works on the line. The filling is of ordinary bricks, the facework is of brindled Staffordshire bricks, the filling in over the arches between the spandrel walls is of cement concrete, and for strengthening hoop iron is built into the piers, walls, and arches, and a layer of asphalte is laid over all the arches. The concrete filling is composed of five parts of gravel and two of sand to one of cement, the proportion therefore of seven to one of the foreign ingredients to the cement. Above the crown of the arch ashes and cinders are used for filling in, and 3 in. drain pipes lead off the overflow of water. The water is allowed to run down or filtrate through a dry lining placed at the back of all abutments, so that it may not penetrate in any degree the walls themselves.

A little further south is another junction, made for the purpose of enabling the Great Northern Company to run its trains from Stafford, Burton, and Derby over the line of the Great Central Company into the Nottingham Central Station. Approaching Nottingham, at the next station, New Basford, a large shed for storing and cleaning carriages has been erected, and provision is also made for the manufacture of gas for the lighting of the carriages, a full illustrated description of which will appear in our second article.

(To be continued.)



MACHINERY, APPLIANCES AND PROCESSES.

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

COMBINED ACETYLENE AND OIL-GAS.

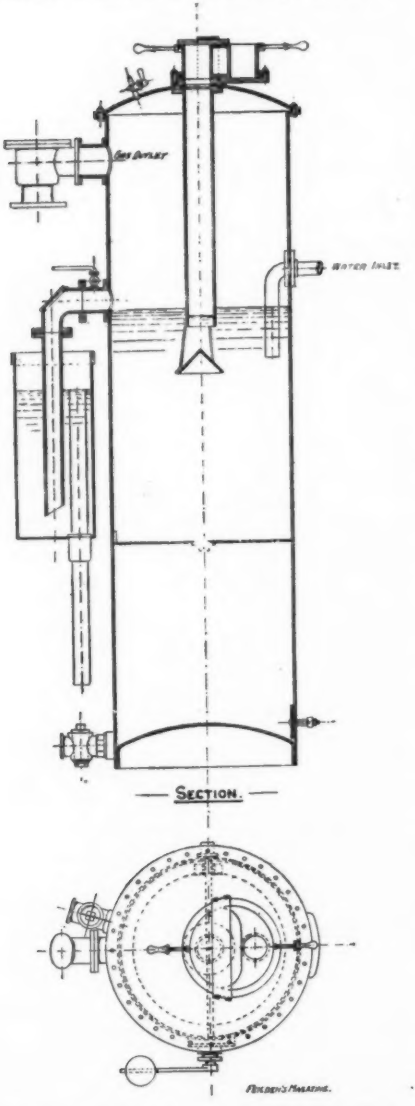
AN IMPROVED SYSTEM OF RAILWAY-CARRIAGE LIGHTING.

For about twenty years past the ancient and funereal oil-lamp has been advantageously superseded for railway-carriage lighting by the bright and cheerful compressed oil-gas light in almost all countries where railways exist. The extent to which this greatly superior method of illumination has been adopted may be realised from the following figures, which were correct at the time they were collated, namely, at the end of 1896, but which have now to be taken plus subsequent additions which are considerable. At that date Germany, the cradle of the system, had about 30,145 carriages and 2,944 locomotives fitted with Pintsch's compressed oil-gas lighting system; England had about 15,400; the United States, 7,902 carriages, which, with the carriages thus fitted up on the principal lines of Australia, Canada, India, Brazil, Argentina, and other countries made a total of 75,000 and 3,005 locomotives then fitted with that system. To these figures must be added a number of carriages in England which are illuminated by oil-gas but which are not fitted up on the Pintsch system. Satisfactory as this system is, both as regards the railway companies and the public, as evidenced by its extensive adoption, the advent of acetylene gas suggested to the executive of Pintsch's Lighting Company, of 38, Leadenhall Street, London, a possible means of improvement. The remarkably high illuminating power of the new gas pointed it out as a promising adjunct to the ordinary oil-gas system, and directly calcium carbide was conveniently obtainable, Pintsch's Company set about utilising it. They at once commenced experimenting with the view of combining and compressing the two gases so as to be able to use them for railway-carriage lighting under the same conditions as those which govern the employment of oil-gas by itself, and using the same travelling plant and illuminating appliances.

It would serve no practical purpose to follow the company through the various phases of its protracted researches and exhaustive experiments. Suffice it therefore to say that towards the close of last year they succeeded in perfecting a combined system of producing a mixture of the two gases which is now being advantageously used on the State railways in Germany under the same conditions as compressed oil-gas alone. This combination, moreover, has received the approval of our own Government. It may help to a clear understanding of the combination system if we here briefly explain the ordinary Pintsch arrangement. In this latter system, as in use on railways, the oil-gas is manufactured in a retort house, and is first stored in a receiver at a pressure of 150 lb. per square inch. It is then charged at a pressure of 100 lb. per square inch into steel cylinders, one or more of which are fixed under each railway carriage. From these cylinders the gas is conducted to the burners in the carriage where it is consumed at a pressure of $\frac{3}{4}$-inch water column. The same pressures are adopted with the mixed gases. A working plant for the demonstration of the combination system has been put down at the company's works, Dover Wharf, Limehouse, which we recently inspected in operation. The combined system does not necessitate any alteration whatever in the oil-gas producing plant, so that whenever that is in use it is in no way disturbed, the acetylene plant being simply an addition.

In practice, the plant and machinery are located in a special building, as shown in sectional elevation and plan in our engravings on page 113, which illustrate the latest design of the Pintsch combination apparatus. The building is about 29 feet long, by 36 feet

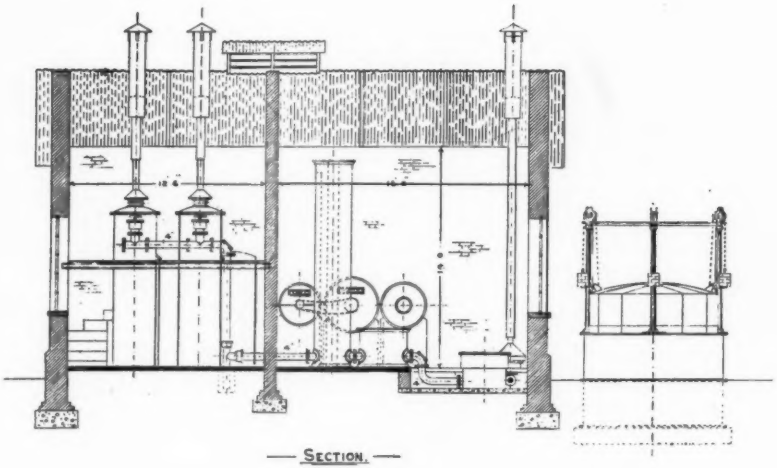
deep, and 14 feet high, and it contains two acetylene generators, one being held in reserve in case of a breakdown, and also in view of repairs being needed. The acetylene gas passes from the generator to the condenser by a 4-inch pipe, and from the latter to the washer by a similar pipe. A 4-inch pipe conducts the acetylene from the washer to the purifier, whence it passes to the meter by another 4-inch pipe. From the meter it passes to the acetylene gasholder through a 3-inch pipe. The mixture of the gases is effected by means of two mixing meters of different capacities. They are simply wet gas meters, and are geared together in the required proportion, so that no more and no less gas can pass through them than their respective revolutions will allow. The oil-gas is conducted from the adjacent oil-gas plant through a 2½-inch pipe to the larger of the two meters, and the acetylene gas through a 2-inch pipe to the smaller one. The gases combine as they leave their respective mixing meters in the proportion of 80 per cent. of oil-gas and 20 per cent. of acetylene, or in any other proportions that may be required. The mixture is conducted through a 2½-inch pipe to the mixed gas-holder, and from thence it passes by a 2-inch pipe to the compressor, which is situated in the oil-gas works. There the combined gases are compressed up to ten atmospheres, or 150 lb. per square inch, and stored in the travelling gasholders. From thence it is charged as required into the steel cylinders fixed under the railway carriages, and conducted to the burners in the carriages.



SECTIONAL ELEVATION OF ACETYLENE GENERATOR DESIGNED AND PATENTED BY PINTSCH'S LIGHTING COMPANY.

The acetylene generators are of a special type, having been designed and patented by Pintsch's Company. One of these is illustrated in sectional elevation and plan on this page. It is on the non-automatic principle, and consists of a cylindrical vessel of galvanised iron having a water overflow with a water seal and a drain pipe. A short distance from the bottom of the body of the generator is a perforated metal disc, which is carried on trunnions and actuated by a lever and counterweight, and having a stop to retain it in a horizontal position. At the top of the generating chamber is a charging drum which can be revolved. This drum contains two receptacles for the calcium carbide, and on the drum being revolved the receptacles are brought alternately over the charging tube of the generator. The carbide falls upon a spreader beneath the surface of the water, by which it is distributed equally over the perforated disc. As will be seen, there is an inlet for water at the side, and an outlet for the gas at the top. There is also a sludge valve for drawing off the residue, a man-hole for cleaning-out purposes, and a water column gauge.

In starting to work, the cylinder is charged



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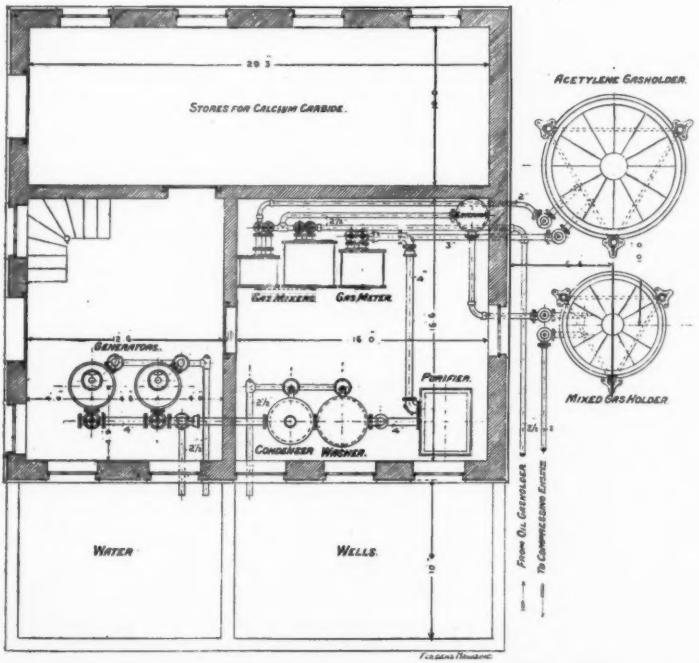


SECTIONAL ELEVATION AND PLAN OF THE PINTSCH COMBINATION APPARATUS.

with water and the perforated disc fixed in a horizontal position. The calcium carbide is then fed in known quantities through the charging drum, and gas is generated and passes away to the condenser. After a given time the disc is turned over into a vertical position, when the residuals fall from it to the bottom of the generator, whence they are removed as often as necessary through the hand-hole. The gauge indicates the pressure in the generator, and acts as a safety valve if the pressure rapidly increases. The generators are fed and attended to from a platform, and the charging drums are continued upwards as tubes into ventilating hoods, into which they open. Should any gas happen to escape, it is conducted away through the hoods to the outer atmosphere. The building is divided into three compartments, one for the generators, another for the condenser, washer, purifier and meters, the third being the calcium carbide store. The roof of each compartment is fitted with a louvre ventilator.

Having described the means by which this desirable process of enrichment is effected, let us next turn to the practical results accruing therefrom. One of the first and perhaps the most important, is, that after a careful and searching investigation, which was carried out by Her Majesty's Inspectors of Explosives at the Pintsch Company's Works, the system has been approved of by the Home Office. By an order of the Secretary of State, dated the 28th of March last, permission is given for oil-gas containing 20 per cent. of acetylene to be used under a pressure not exceeding 10 atmospheres or 150 lbs. per square inch. The Home Office authorities, however, were not the only investigators of the system, inasmuch as Professor Vivian Lewes carried out a series of experimental trials at the Limehouse works with both the oil-gas and the combined gases. The object of his experiments was of a twofold nature and of a distinctly practical character. In the first place, he desired to ascertain to what extent the addition of acetylene increases the illuminating value of the oil-gas, and in the second, whether the use of such a mixture is possible from an economic point of view. In the trials, the mixed gases were used in the proportions of 80 per cent. of oil-gas and 20 per cent. of acetylene, the tests with both the oil and the mixed gas being made at a pressure of 150 lbs. per square inch. The results showed that the illuminating value of one cubic foot of oil-gas was 7·4 candles, and that of one cubic foot of the combined oil and acetylene gases 15·6 candles, or an increase of about 110 per cent. The compressed gas, however, being required for the specific purpose of railway-carriage lighting, the oil-gas and the mixture were next burned in ordinary railway carriage lamps for their illuminating power at various angles below the horizontal, the Dibdin radial photometer being used for the comparison, and the gas being burned at a uniform pressure of one inch. Under these conditions, and when measured at all angles, the same ratio of increase in illuminating power was obtained as in the previous trials.

The first point of the enquiry—namely, the increased lighting power of the combined gases—having been thus satisfactorily established, attention was given to the second or commercial phase of the question, and to this we find Professor Lewes giving an equally satisfactory answer. Taking the price of calcium carbide at £16 per ton at the works and £20 per ton delivered, the acetylene will cost £1 18*s.* per thousand cubic feet in the gas-holder, and 200 cubic feet will therefore cost 7*s.* 8*d.* The cost of the compressed oil-gas ranges from 6*s.* to 12*s.* per thousand according to locality. Taking the oil-gas at 8*s.* per thousand, 800 cubic feet will cost 6*s.* 5*d.*, whilst the cost of 200 feet of acetylene being 7*s.* 8*d.*, the cost of 1,000 cubic feet of the mixture will amount to 14*s.* 1*d.*, as against 8*s.* But then the mixed gas possesses double the illuminating power of the oil-gas, so that there is an economy of 1*s.* 11*d.* per thousand. The saving, of course, increases as local circumstances cause the oil-gas to be dearer and diminishes as it cheapens, until with oil-gas at 6*s.* 6*d.* there is practically no difference. There are, however, several other advantages which even in such a case would render the use of the mixture desirable. In the first place, the light-giving value of the gas being double, it will take twice the time for the cylinders at present in use to become exhausted, so that once charging in place of twice in the same period of time will follow, a gain which cannot be over-rated. Another point is that with oil-gas alone, liquid hydrocarbons are condensed in the cylinders during compression, and revaporising when the pressure becomes low, serious variations are caused in the illuminating value, and there is a tendency to smoking in the lamps. No such condensation takes place with pure acetylene at the pressures employed, and the presence of 20 per cent. of this gas reduces the trouble and tends to equalise the illuminating power.

Since Professor Lewes made his tests, further experimental trials have been carried out at the Company's works, at some of which we were present. The results of these trials are a distinct increase in the illumi-

nating value of the mixed gases. It is also found that taking the calcium carbide at £16 per ton at the producing works, or £20 per ton delivered, and taking each pound weight of calcium as producing 5 cubic feet of acetylene, and making reasonable allowance for wages, interest on capital, depreciation, repairs and renewals to plant, &c., the price of acetylene comes out at £1 18*s.* per 1,000 cubic feet. If, therefore, 1,000 cubic feet of acetylene at 38*s.* is mixed with 4,000 cubic feet of oil-gas at 5*s.* per thousand—a reasonable price—a gas is produced at 11*s.* 7*d.* per thousand. But inasmuch as the mixture is of double the illuminating value of the oil-gas, the price as against the latter comes out at 5*s.* 9½*d.* per thousand, light for light. It therefore comes to this, that whenever oil-gas at a particular place chances to cost 7*s.*, or more than 7*s.* per thousand, including interest, depreciation, &c., it is cheaper to mix it with acetylene than to use it by itself. In fact, as already observed, the more the oil-gas, owing to local circumstances, chances to cost, the more it pays to mix it with acetylene and double its illuminating power.

Satisfactory as the results of carriage lighting by means of compressed oil-gas are to the railway companies who have adopted the system, the opportunity which now presents itself for materially improving their position should not be missed. German railway managers, as well as those of some other lines on the Continent, have shown their intention to go with the times by adopting the combined system, and English companies will consult their own interests by following—since it is too late to initiate—such an example of progress.

Acetylene Installation at a Public Hall.—Lord Pirbright having presented the village of Pirbright with a public hall, an acetylene gas plant has been installed therein by the Thornton-Scarth Automatic Lighting Syndicate, Ltd., of Birmingham. The installation consists of three hanging four-arm pendant lamps, having four 50-candle power burners, two two-arm brackets with 25-candle power burners from the stage end of the hall, besides sundry lights in the lobbies, cloakrooms, &c., making the whole installation one of about fifty lamps.

A few years ago a Magazine such as this, whilst doubtless filling an important gap, would not have possessed anything like the value the proprietors claim for it to-day; but in nothing so much as in the domain of industry and commerce do we realise the adage "*Tempora mutantur et nos mutamur in illis*," and we prognosticate that the potential importance of FEILDEN'S MAGAZINE will be contemporaneous and commensurate with the march of events.

AUTOMATIC WEIGHING MACHINES

FOR COAL AND OTHER MINERALS.

A REVOLUTIONARY INNOVATION.

In carrying out our announced intention of providing our readers with information concerning the most up-to-date inventions which have for their object the furtherance of industrial progress, we are pleased to be able in this our first number, to illustrate and describe Ingrey's Patent Mineral Weighing and Recording Machine, which is now practically introduced, and which would seem to be destined to revolutionise the present system of dealing with coal and other minerals.

Numerous attempts have been made from time to time to automatically weigh coal, but the problem presented so many difficulties that little or no success has hitherto been obtained. The prevailing idea appears to have been to collect the coal as it descends a shoot and cause it to be received into a receptacle capable of overbalancing when a predetermined weight has been accumulated, and to cut off the supply whilst the receptacle turns down and delivers the load—each movement being registered by a counter. Such an arrangement might possibly be made to answer with corn or other granular materials; but with coal, which varies in size, class, and condition, the difficulties would seem to have been insurmountable.

With the Ingrey Machine no overbalancing platform or receptacle is employed, and no definite weight of coal is collected. Each load is delivered by a "grab" or skip, or by a shoot, and no matter how much the loads may vary, they are shot into a hopper and automatically weighed, the weight of each load being added on to the previous total, so that the amount passed through the machine can at any time be ascertained by reference to the indicator.

It will, of course, be understood that with any weighing machine in which a weighbeam is employed, the use of "knife-edge" centres is indispensable, but if these knife edges were subjected to the effect of a falling mass of coal they would soon become destroyed, and accuracy of weight could not be obtained.

According to this invention the bucket or coal receptacle of the machine is rigidly supported clear of the knife edges when the load is received, and when the supports are withdrawn the bucket is gently lowered on to knife centres, and the weight of the coal contained therein, operating the weighbeam and levers, registers itself on the indicator. The amount of motion to lower the bucket on to the knife edges is very small, not more than a quarter of an inch of movement being required.

The empty bucket when upon its centres is, with the weighbeam and levers, accurately balanced by a balance weight, so that it is only the weight of the contents of the bucket which can put the indicator into operation.

In cases where hydraulic power is used to work the crane or other lifting machinery, the necessary motion to the machine can be very conveniently applied by means of a small hydraulic cylinder, into which a small quantity (some 5 or 6 pints) of high pressure water is admitted and exhausted respectively by the action of a valve worked by the movement of the crane, so that whilst the crane is engaged in obtaining another load the following functions are performed:—

(*a*) Lowering the bucket on to the knife edges of the weighbeam.
(*b*) Registering the weight and adding the same to the previous total.
(*c*) Opening the door or doors of the bucket and discharging the coal.
(*d*) Retaining the door in its open position for a few seconds of time, to allow the last pieces of coal to escape.
(*e*) Closing and locking the doors.
(*f*) Restoring the machine to its normal position, free from the knife edges, and rigidly supporting the bucket ready to receive the succeeding load.

The whole of these operations are performed in 25 to 30 seconds of time.

PORTABLE WEIGHING MACHINE ARRANGED FOR DELIVERY TO A BARGE BENEATH.

When steam, or motive power other than hydraulic, is employed to operate the crane, the needful motion to the weighing machine can be transmitted by a rod or chain. The amount of power required is very trifling, as all that is necessary is to remove from and restore to the bucket the supports before-mentioned—the coal practically weighing itself.

By an improvement just made the inventor is able to dispense with any connexion with the crane, and to utilise the force exerted by the falling of the coal into the bucket to operate the machine itself. By this arrangement it is not necessary for the crane to deliver the coal into the hopper, or to adjust the relative positions of crane and machine, as the coal may be delivered by a shoot, and the machine can receive the product from two cranes. In cases where this plan has been adopted and two cranes are employed, upwards of 150 tons of coal are dealt with each machine per hour.

The indicator consists essentially in an arrangement of compound levers and a spring, the movement of which latter is transmitted by a rack and pinion to a hand or pointer, so that the weight of each load is indicated on a dial, after the manner of a spring balance weighing machine. The same movement, however, also operates a train of wheels and gives motion to a set of small dials, which respectively represent *thousands*, *hundreds*, *tens*, *units and decimals of a ton*, the total reading being 9999·99 tons, the next decimal movement restoring the indicator to zero.

It is needless to say that this indicator is fitted into a dust-proof case, and is fixed in a position where it is not likely to be damaged. The machines themselves are necessarily made of great strength, so as to be able to withstand the rough and heavy treatment to which they are subjected, particularly where

large Welsh coal is dealt with. We are informed that in an installation where eight of these machines are employed, some 25,000 to 30,000 tons of coal are passed through them per week.

The importance of this invention would seem to be manifest, as not only is a correct record of the weight obtainable, but a very great saving of time is effected. This will be understood when it is considered that under ordinary circumstances the weight has to be ascertained by means of hand appliances, and the record entered in a book by an attendant; this entails much expense and, of course, considerable waste of time, so much so, indeed, that in numerous instances weighing is entirely dispensed with, and the weight merely *assumed*.

The first illustration shows a portable machine arranged to travel upon a timber gantry, to receive the coal into the hopper above, and to deliver it by a shoot to a barge beneath. The coal is delivered by a "skip" or tank, containing anything up to 1 ton. This of course necessitates the employment of a man to tip over and empty, which would not be the case if a "grab" were employed.

The second view illustrates one of nine two-ton machines, which are mounted upon the top of portable steel structures running upon rails, the cranes to supply them being also portable, so that their positions can be regulated to suit the hatchways of the ships which are to be unloaded.

Machines of all sizes are made and can be arranged for various conditions of cranes and delivery.

It appears to us that these machines are of considerable value, not only for purposes of coaling and de-coaling ships, but for large users of coal, such as brewers, iron works, mills, electric light stations, sugar refineries, gas works, etc., etc., whilst one of the most important applications of the invention is for collieries, for the purpose of weighing and recording the coal delivered from the pit, and we are informed that the inventor (Mr. Charles Ingrey, C.E., of 32, Victoria Street, Westminster, S.W.) is now busily engaged in this direction.

WEIGHING MACHINE MOUNTED ON PORTABLE STEEL STRUCTURE.

It is the earnest hope of the Proprietors, that FEILDEN'S MAGAZINE will be largely the instrument whereby a fairer system for the interchange of commodities will be brought about between the two great English-speaking nations, in order to exemplify that the outward and visible show of the two flags flying side by side, "to the mutual benefit of the commerce of both," is not a mere figure of speech.

PROGRESS IN STEAM STOP VALVES.

AN INTERESTING ADVANCE.

THE great increase which has taken place of late years in boiler-pressures has necessitated great improvements in stop valves. The pressures have now reached a stage where the ordinary type of stop valve practically fails. To meet the present requirements, a valve to do the work effectively must be designed :

1st. To stand high pressures.
2nd. To ensure absolute tightness when closed.
3rd. To be easy in opening and shutting.
4th. To be free from all chance of jamming.
5th. To require no other means than the handwheel to close it.
6th. To exert no pressure on the gland when closed.
7th. To guard against any possibility of spindles being twisted off or bridges broken.

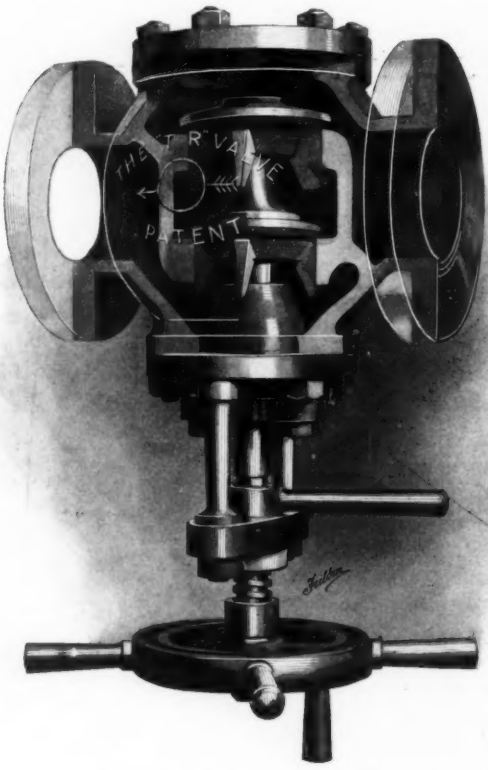


FIG. 1.—THE "T.R." STRAIGHTWAY STOP VALVE.

It often happens that if a stop valve leaks, the first thing done is to try to screw the valve down tighter, either with a spanner or with a bar inserted in the handwheel, thus throwing undue strains on the spindle and bridge, which often result in serious accidents. To overcome these difficulties, an independent double-check stop valve, known as the "T.R." stop valve, was patented some three years back by Messrs. Templer & Ranoe, of Rugby, and has during the above period been tested with such excellent results as to justify their now placing it before the engineering community. It remained absolutely tight under a pressure of 200 lbs. per sq. in. for three years, never requiring to be ground in, as is so often necessary with the ordinary type of valve now in use. As every engineer knows, the seats have often to be re-faced in the lathe, a proceeding which is both inconvenient and expensive.

Fig. 1 shows a straightway "T.R." stop valve fitted with internal byepass. The lower valve is coupled to the spindle, but free to move. The upper valve and the byepass are connected to the lower valve, but have about $\frac{3}{16}$ in. clearance.

When opening, the action is as follows :—Upon turning the handwheel the lower valve

is opened about $\frac{3}{16}$ in. On continuing the turning the byepass opens ; this allows the steam to pass and put the valves into equilibrium. On still continuing the turning the upper valve opens. *When closing* the upper valve closes first and then the byepass, these valves being held down tight on their seats by the steam pressure alone. The lower valve is then pulled down on its seat by the screw of the handwheel. In this way both valves are closed, forming an independent double check, and having the advantages

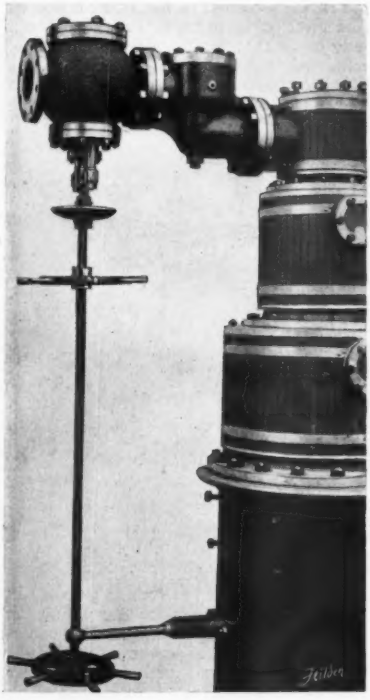


FIG. 2.—ILLUSTRATION SHEWING ATTACHMENT OF VALVE TO WILLANS AND ROBINSON ENGINE.

of no undue strains on any of the parts. The valves cannot jam, and are easy in working as a regulating or starting valve. When closed they are absolutely steam-tight, and there is no strain on the spindle, or steam-pressure on the gland. The advantages of this form when used as a boiler stop-valve are great, as it takes the place of two ordinary valves, as may be clearly shown as follows :—Suppose a battery of boilers feeding one main steam-pipe. In this case the outlet flange of the valve is fixed to the boiler outlet, and the other to the steam-pipe connecting to the main. Should it then be desirable to shut one boiler down for repairs or washing out, the steam in the main steam-pipe is allowed to close the upper valve, and the lower is closed by the handwheel. A drain cock fixed between the two valves is opened, and thus absolute safety is ensured to anyone entering the boiler.

Fig. 2 shows the external appearance of the valve as fitted to a Willans engine.

These stop-valves have been fixed on mains and engines in a number of electric lighting stations and mills in England and abroad, and as engine stop-valves on the well-known high-speed engines of Messrs. Willans & Robinson, Ltd., Victoria Works, Rugby.

To meet the demand for these stop-valves a company has been formed, and new works are now completed at Coventry, fitted up with the most modern plant for the rapid production and high-class workmanship that high pressure valves require.

THE LATEST DESTRUCTIVE MACHINE.

THE new quick-firing gun which was exhibited by the Colt Company at Runnymede on the 20th July, appears to offer boundless possibilities. Roughly speaking, this latest engine of destructiveness weighs 40 lbs., can be worked by a single man, and is capable of firing thousands of rounds of cartridges without ceasing. Of course the tests were not very severe, but the gun certainly acquitted itself in a manner which raised high hopes in the breasts of the experts who saw it. But what—exclaims a daily contemporary—an awful prospect this terrible potentiality of killing opens up. A single horseman or foot soldier can carry with him a gun capable of killing its hundreds at a range up to 1,500 yards. It is a maxim that the more destructive modern war machines become the less deadly in war. Certainly, the more potentiality for destructiveness can be concentrated, the less need for large armies. If one man can kill his hundreds and can command a square mile of territory by himself, the huge cumbersome armies of the past will be no longer necessary. It is possible that this latest patent of the Colt firm will have more effect on the reduction of European armaments than all the fine phrases of The Hague delegates.

GEIPEL'S ADMIRALTY STEAM TRAP.

AN APPARATUS FOR THE EFFICIENT DRAINING OF STEAM PIPES.

It is frequently thought that Government departments are conservative and slow to adopt improvements. This, however, cannot be urged against the British Admiralty so far as concerns the adoption of high pressure steam. In that respect, at least, they are ahead of current practice amongst Marine engineers, for in nearly all of their recent vessels a steam pressure of 300 lbs. per square inch is used.

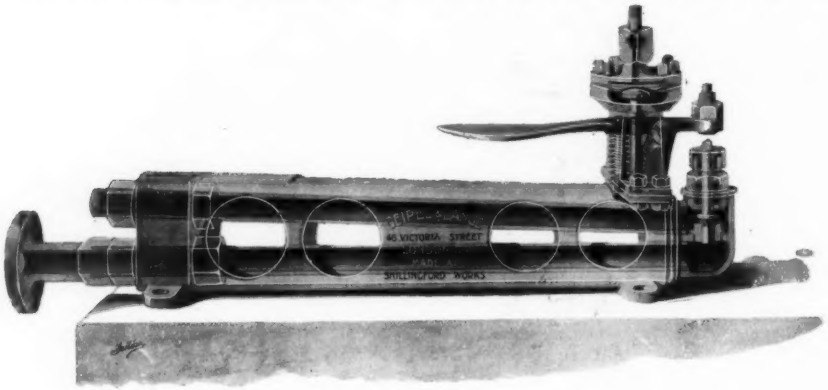
With the use of these high pressures, the importance of the efficient draining of the steam pipes and engines has been more and more pronounced. Serious accidents have happened through the collection of water in steam pipes, resulting in the fracture or bursting of a pipe or valve. Moreover, the disadvantage under which the engines work when there is water present has become more apparent.

The old-fashioned system of draining by hand has been found to be erratic, unreliable and uneconomical. It is impossible to regulate the opening of a drain cock by hand so that water is passed out just as it is condensed, for condensation does not take place regularly and at even rates, but depends upon many conditions, while priming may take place at any time. It is indisputable that many of the accidents which have happened are the direct result of hand draining, and that they would in all probability have been avoided by automatic draining by efficient steam traps.

For these and other reasons, the Admiralty are now fitting steam traps on all of their steam pipes, both main and auxiliary, and there can be but little doubt that in this respect also they are in advance of the mercantile marine where hitherto, with few exceptions, the draining has been done by hand.

The design of an efficient steam trap is attended with considerable difficulty. Two methods of obtaining the controlling power for opening and closing the valve are available, one by gravity or flotation, the other by thermal expansion of metals or liquids.

The force of gravity, *i.e.*, the flotation of a body or receptacle, the motion of which is transmitted to the valve, is, of course, limited by the size or displacement of the float. For high pressure, therefore, it is necessary either to use a large float or to reduce the opening of the valve, while to close the valve quite tight to shut off the steam, there must be a considerable margin of power over and above that which is required for holding the valve merely against the pressure of the steam. Then there is required a box or case of sufficient size to contain the float, and generally the levers necessary to transmit the motion of the float to the valve. When such a box is under high steam pressure, it must not only be made proportionately strong and heavy, but the joint between the cover or door for giving access to the working parts must also be made suitable for high pressure. For these reasons it is obvious that to operate a valve for large and rapid discharge at high pressure, the whole apparatus must be bulky and expensive.



THE "GEIPEL" STEAM TRAP.

Thermal expansion, however, affords a force for closing the valve, which is limited only by the strength of the materials used. There have been objections to the use of expansion traps in the past, partly because of the small movement available for opening and closing the valve, and partly because when these traps are adjusted to a given pressure, any excess of that pressure causes cutting and straining of the valve, while a fall in pressure opens the valve and lets out live steam.

For usual purposes and where the variation in pressure is not excessive, the ordinary Geipel Trap overcomes these objections.

In the case of the medium size of the Geipel Trap for example, the linear expansion of the brass tube with a temperature of say 300° F. above the atmosphere is only 3/1000ths of an inch and of the iron tube about one half of this.

This movement, which as it stands is far too little to open the valve, is altered from a direction at right angles to the base to one parallel therewith, while it is multiplied about one hundredfold. Thus the objection of too little movement which is found with expansion traps is overcome.

Coming now to variations in pressure, the

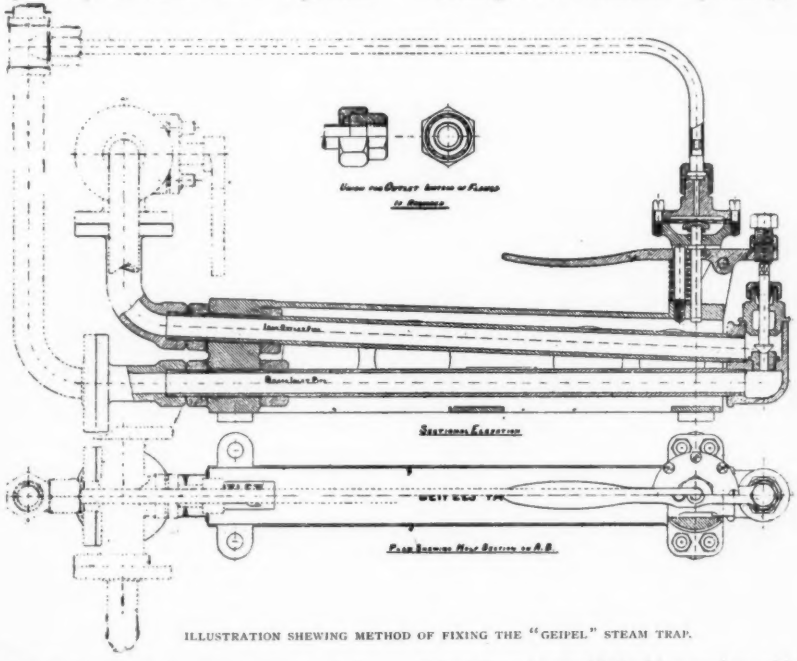


ILLUSTRATION SHEWING METHOD OF FIXING THE "GEIPEL" STEAM TRAP.

Owing to the triangular arrangement of the two expansion tubes, the motion is enormously multiplied. This motion may be expressed algebraically thus :—

If X = motion of the apex parallel to the base,

a and b = the two sides of the isosceles triangle,

and c = the base of the isosceles triangle,

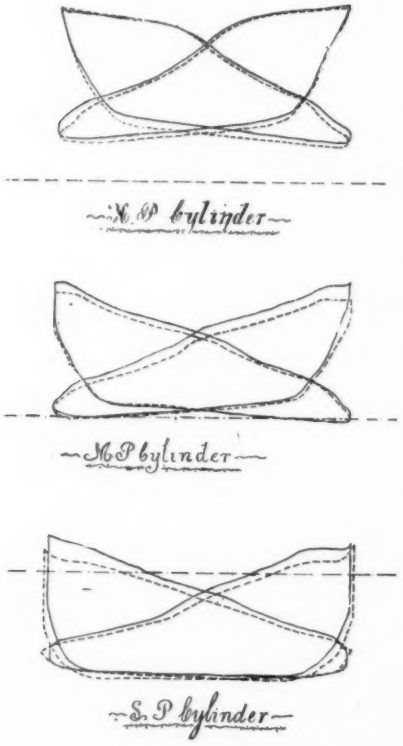
then $X = \frac{a^2 - b^2}{2c}$,

so that by making c small, X becomes great.

Geipel Trap is provided with a spring which yields should the expansion exceed that for which the trap is adjusted, so obviating damage by straining or cutting the valve ; this meets all variations found in usual practice.

But the English Admiralty require a trap which shall be tight against steam at pressures varying from 300 lbs. down to atmospheric pressure, and at the same time discharge water promptly as soon as it condenses. In other words they require a trap which, without adjustment, will hold tight with steam at from say 420° F. to 220° F. and yet will discharge water when at 410° F.

Their reasons for such requirements are that a considerable time is occupied in raising steam, during which it is the custom to open all steam pipes, so that the temperature of the whole system may rise gradually and simultaneously, while the working pressure is frequently very much less than the maximum. This might be met by readjusting the traps by hand, but on vessels of war the whole of the steam apparatus must be ready in case of emergency to work at the full maximum pressure—there is no time for adjustment of steam traps or any such apparatus; consequently such traps, if adjusted for full pressure, will allow live steam to blow all the time that the pressure is much lower than the maximum.



INDICATOR CARDS FROM S.S. REPTON, SHEWING IMPROVEMENT DUE TO THE USE OF GEIPEL'S STEAM TRAP.

N.B.:
DOTTED LINES WITHOUT TRAPS = 847 I.H.P.
FULL ,, WITH ,, = 903 ,,

It would appear at first sight that an expansion trap could not be adopted, owing to the anomalous conditions above mentioned. In this new type of trap, Mr. Geipel has, however, entirely overcome the difficulty. To attain this object two forces are used, one due to the difference of temperature causing expansion of the tubes, as before described, the second due to the pressure in the pipes, which controls the adjustment of the trap and alters it according to the pressure. The arrangement is shown in the drawing on page 120.

The expansion tubes and valves are the same as in the ordinary type. The lower or brass tube is connected to the steam pipe, the upper or iron tube to the discharge. The valve is at the apex. When the tubes are cold they are contracted, the apex is down and the valve free to open. When steam enters the brass tube it expands and raises the apex and valve against the stop in the end of the lever, the valve is then closed. When water forms, it enters and contracts the brass tube, and the valve is again opened until steam enters, and so on.

The position of the stop in the lever determines at what point the valve shall begin to open, and this is operated by the diaphragm, which is subjected to the pressure in the steam pipe or receptacle to be drained. When the pressure is low, the stop in the end of the lever is low, and conversely, when the pressure is high, the stop is raised. The amount of movement allowed is exactly that which is necessary to suit the position which the apex or valve occupies at low and at high pressure. This precise adjustment is obtained by the use of a helical spring against which the diaphragm works, and no difficulty has been found in practice in securing this adjustment. As in the ordinary type, this trap may be blown through by hand by pressing down the lever, and there is the same facility for quickly removing the valve, which may be done by simply unscrewing the cover.

The sketch on foregoing page shows the method of fixing generally adopted on H.M. vessels. It will be seen that a three-way cock is provided on the discharge, so that it may be opened to the atmosphere, and the action of the trap may thus be periodically tested without breaking any joint. The water discharged from the various traps is collected and returned to the boilers.

The importance of the efficient draining of all steam pipes and receptacles requires but little emphasis, whether it be viewed from the standpoint of safety to life and machinery,

economy in fuel, or otherwise. We have before us, however, some interesting diagrams taken from the s.s. "Repton," on which Geipel traps have been in use for three years. We reproduce them (opposite page) as they illustrate markedly the improved working of the engines.

It will be seen that the pressure in the intermediate receiver is increased from 44·5 to 50·5 lbs., that is, 13·5 per cent., while that in the low pressure receiver is increased from 2·5 to 4·5 lbs., that is, 80 per cent., the boiler pressure being the same in each case, while the total indicated horse-power is increased from 847 to 903.

Similar results have been obtained by Professor Wrighton at Newcastle-on-Tyne, who found by a series of tests that the efficient draining of the engine by steam traps increased the power of the engine by about 5 per cent., while the steam used per hour was about 5 per cent. less.

Apart from the saving of steam and make-up feed water, and other advantages, this increase in the power of the engines has a direct capital value which is enormously greater than the small cost of the traps themselves. It means that smaller and lighter engines may be used for a given power, or that greater speed and distance may be attained by the same engines.

On the new Royal Yacht there are being fitted no less than 25 of these traps; they are also in use or are being fitted in the following vessels of war, viz. :—

H.M.S.	Arrogant	H.M.S.	Magnificent
,,	Furious	,,	Pelorus
,,	Salamander	,,	Psyche
,,	Prometheus	,,	Perseus
,,	Britomart	,,	Bramble
,,	Hyacinth	,,	Niobe
,,	Proserpine	,,	Glory
,,	Vindictive	,,	Implacable
,,	Sheldrake	&c.	&c.

Amongst other navies which have adopted this trap are the German, Russian, Dutch, and Japanese navies, while it has been tested by the French naval authorities, and obtained the official approval of M. Lockroy, the French Minister of Marine. Full particulars may be obtained from Geipel and Lange, 68, Victoria Street, Westminster.

SUBSCRIBERS to "FEILDEN'S MAGAZINE" are reminded that the Editor will be pleased to hear from them with advance particulars of any new machinery or specialities they may be bringing out or interested in. Nothing mediocre, stale, or commonplace will, however, find room in these columns.

A NEW MECHANICAL STOKER FOR BOILERS.

THE attention of steam users is being constantly called to apparatus for increasing the heating power of fuels used in boiler furnaces. This question being intimately bound up with the smoke consumption of furnaces is under the circumstances of great interest to all manufacturers. There is much activity, and rightly so, in the application of the orders relating to the suppression of smoke from works, and the summonses are numerous, although the magistrates often give the delinquents another chance to escape from the legal consequences of emitting volumes of black smoke.

It is in installations of fair size, where the generation of steam is fairly regular, that the use of mechanical stokers is better appreciated than elsewhere. In fact these are the most favourable conditions for getting a good result from a fuel, and, as a corollary, for preventing smoke.

These remarks are called forth by a new stoker of this kind which Messrs. Ransomes and Rapier, of Ipswich, have just introduced with practical success, and a description of which will, we think, be interesting.

Our illustrations, which, as will be seen, represent both a transverse and a longitudinal section of the apparatus *in situ*, and its connections with the firebox, show the application of it to a boiler with two internal flues; its working, the principle of which has already been applied many times, consists in throwing the coal on the grate at short and frequent intervals and in such a way that two successive charges never fall in the same place; it also presents innovations of an essentially practical nature, which afford real advantages.

The fuel is distributed automatically, in fixed quantities, before a kind of throwing shovel, actuated by means of gearing and a spring trigger; at the same time the fire bars are given a reciprocating movement, which breaks up the clinker and cinders and carries them gradually to the ashpit arranged at the back of the grate.

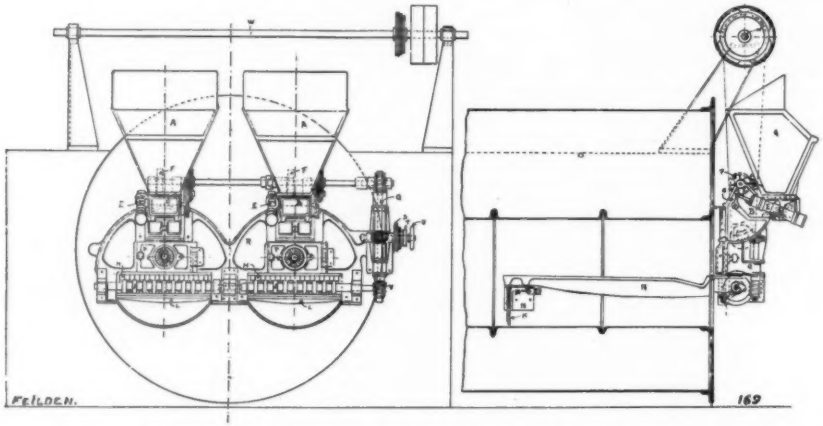
The power for working the stoker is taken from the counter-shaft W, connected to the power system by belting, and provided with fast and loose pulleys. By means of a three-grooved cone and rope this shaft works a similar cone S, whose bearing Q is bolted to a prolongation of the boiler-front R. This pulley S, by means of an endless screw gearing, sets in motion a vertical shaft, which at each end carries a similar gearing, giving a

slow rotary motion to two horizontal shafts V and X, placed on opposite sides of the flues.

It is thus seen that the inventor has arranged the stoker so that it may be made to work at three speeds, each corresponding to a different rate of consumption ; in addition, on the shaft of the pulley S is a grooved loose pulley, T, for receiving the rope while not working, and a wheel U to allow the machine to be turned by hand.

The coal put in the hoppers A supported by the boiler-front descends into a box containing an adjustable slide C, receiving a rectilinear reciprocating movement by means of a crank worked at a speed suitably accelerated by a triple train of straight gearing and the upper shaft X. At regular intervals this slide allows coal to fall on the shovel D hinged by steel side arms to an axle pin which carries the trigger G placed in the field of action of a four-armed cam F, keyed directly to the shaft F. This trigger is besides attached by a crank to a powerful recoil spring E, which it compresses during the movement given by the cam, and which, at the moment of release, drives the shovel smartly forward together with the coal on it ; the shovel then returns to its back position, and the slide C again charges it with a definite quantity of coal. In order to distribute the fuel uniformly on the grate the cam has four arms of unequal lengths, which successively more or less compress the spring, and consequently vary the throw of the shovel.

The backward and forward motion of the fire-bars is obtained by the cams J, threaded on a square bearing on the lower longitudinal shaft V, which rotates very slowly by means of its worm gearing. Each of these cams has two projections in different vertical planes ; the one draws forward two bars at once by engaging in recesses formed in the top of their ends, and the other pushes them back by projection heels formed below. The bars are thus drawn forward by about 50 mm. or 2 ins. by two and two in succession, so that they shall not bring with them the clinker and fuel ; when they have all been thus brought into this position there is a slight pause, after which the cams push them back altogether into their first position ; the result of these continued movements is that the clinkers and ashes travel towards the back, and finally at the extremity of the bars fall into the ash-pit, whence they are removed from time to time by the door K. The bars rest freely in front on the bearer L, which completes a guide frame formed by the boiler front, and at the back on the bearer M, carried by two supports N bolted to the sides of the interior flue. These supports also carry the door K of the ash-pit.



TRANSVERSE AND LONGITUDINAL SECTION OF MECHANICAL STOKER *in situ*.

In an apparatus of this kind the moving parts should be removed as far as possible from the high temperature of the flues, and this desideratum is well obtained here by placing the principal shaft X high above the flues ; its bearings are protected from coal-dust and are easily lubricated. None of the parts of this stoker project into the com-

bustion chamber ; all are bolted to the cast-iron boiler front R. In the centre of the latter is the door P, in which a butterfly register serves to regulate the admission of air to the furnace.

The design of the shovel is particularly judicious ; its two side arms fasten it solidly to a strong pivot running from side to side of the feed-box and turning in long bearings, between which is keyed the trigger ; by reason of its axial position the latter imparts equal forces to the arms of the shovel, which consequently works quite parallel to its axis and throws the coal straight in front of it ; another advantage of this good arrangement of working is that there cannot be any rapid wear ; but however slow the latter may be, the makers do not lose sight of the easy and economical renewal of the wearing parts. To this end the four-armed cam of the shovel is keyed separately on its shaft so as to easily lend itself to detachment and renewal, and the same thing holds good for the fire-bar cams ; these are of chilled cast iron, threaded on a square formed on their shaft, which therefore gets no wear.

Two of these stokers have been on trial for over twelve months on the Lancashire boilers of some cocoa works in London ; not only have they effected a remarkable economy of fuel, but they have also made the use of an inferior quality of fuel possible ; instead of good Welsh coal an inferior kind has been used, the emission of smoke being almost imperceptible. At some large iron works in Durham the managing director has written to say that since the application of these machines the steam production has been increased nearly 75 per cent. This is an admittedly abnormal result, and one which Messrs. Ransomes & Rapier would not in all cases guarantee, as the conditions were not only favourable, but a more suitable class of small coal was substituted for that previously used. It may be mentioned that in order to provide against an insufficient draught in the chimneys, recourse has been had to small steam jets under the bars in the front of the ash-pit.

A letter has been received by the Lancashire Patent Belting Co. from their Milan agents, in which the latter say that one of their belts—one 64 feet by 24 inches—has been placed in the best situation within the Milan Exhibition. "Having been carefully and specially jointed, it is running in fact as an endless belt, and without the slightest click. A large number of users have admired it, and expressed great satisfaction with the trials made, as have also unanimously the committee of the Exhibition itself." The Lancashire Patent Belting Co. have been appointed sole furnishers of belting to the Milan Exhibition.

CIRCULATION IN STEAM BOILERS.

AN EFFICIENT AND ECONOMICAL APPLIANCE.

THE demand for the rapid development of high pressure steam, with the greatest possible economy of boiler space, has once more brought to the front the problems of boiler-construction, and we are reminded of the old story of the candidate for admission to an engineers' association, who, when asked for his qualifications and proofs of ability as an engineer, replied that he had done nothing.

"Haven't you invented anything—a trap or a valve ?"

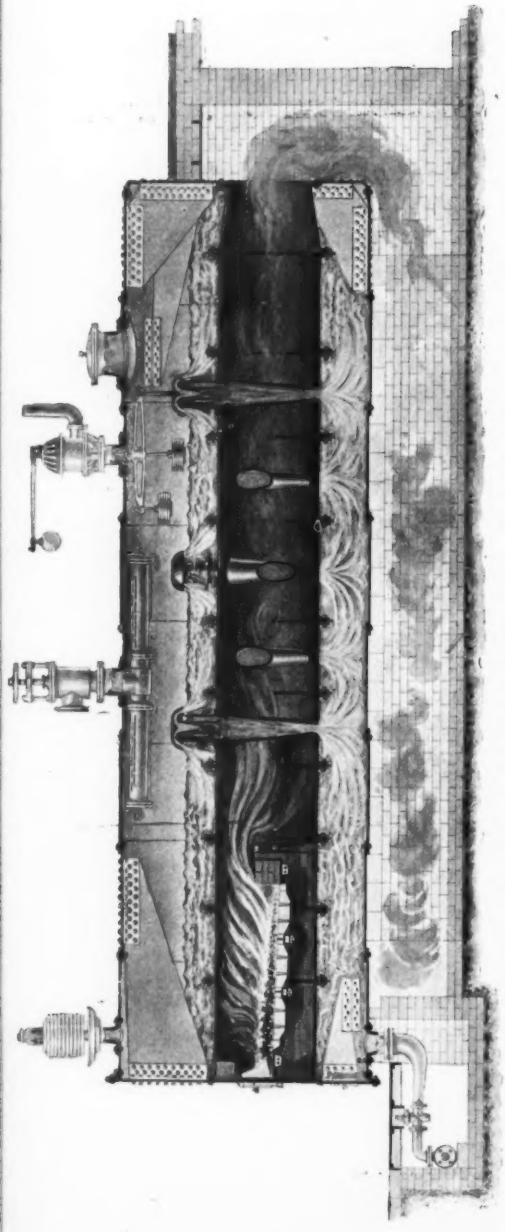
"No."

"Then we cannot receive you," was the reply.

"For forty years," he went on, "I have been trying to make a perfect boiler and have not done it yet. I should think that is qualification enough."

Of all the traditional forms of steam-boiler, those represented by the Cornish and Lancashire types find most favour from the simplicity of their construction and the employment of the material in its strongest form for resisting expansion or compression, viz., the cylindrical. The drawback of want of room is against them in crowded cities and on board ship. One of the most serious defects of these types of boilers arises from the dead water below the furnace tubes, which cannot, owing to the absence of "circulation," obtain the same temperature as the water above the flues. The steam above the flues is at a temperature of 350 degrees or more, and is in contact with the plates at the top of the boiler, while the feed-water which falls to the bottom of the boiler is seldom within 100 degrees of this. The strain on the plates, owing to this unequal expansion, especially when getting up steam in starting a boiler, is very serious, and where boilers have to stand very high pressures any weakening from this cause is much to be deprecated.

One of the reasons for the popularity of the Galloway tubes when first introduced in boilers bearing one-third the pressure of those now being built, was the idea that they promoted the circulation of the water from the bottom of the boiler. The experiments of the late Mr. Lavington E. Fletcher and others have dispelled this idea, and one of the best-qualified of our boiler experts, in commenting upon their use last year, says : "Some recent experiments with a long plain furnace tube show that such tubes fail by crumpling, preserve their elasticity under pressures approaching collapse, and that cross-water-pipes which act as ties as well



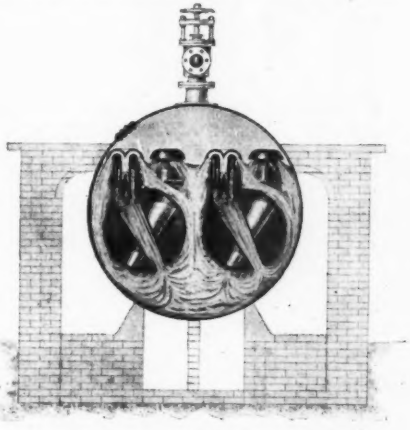
LONGITUDINAL SECTION OF BOILER SHEWING METHOD OF FITTING AND ACTION OF "ACME" CIRCULATORS.

as struts increase the resistance to collapse." The extension of these tubes up to the surface of the water and other devices of a similar character have been tried without any prominent improvement to the boiler in this respect, but the most recent as well as the most successful invention has achieved this most desirable result of complete circulation by isolating each of these tubes as far as its steam-production is concerned, by inclosing the top of the tube with two concentric domes, and causing the steam generated in the Galloway or cone-tube to form a short circuit and in its course to lift a certain quantity of water before joining the steam in the common steam-space of the boiler.

The accompanying illustration shows a longitudinal section of a boiler fitted with these arrangements, which are supplied by the Steam Boilers Circulation Co., Ltd., 43, Barton Arcade, Manchester. A saddle with a double flange is firmly attached by set screws of a special shape to the top of the ordinary cross-water tubes, making a perfectly tight joint with the flue shell. No drilling of the boiler plates is needful. Upon the top of this base the Patent Duplex Dome is fitted, as shown in the sketch, and is held in position by screw-clamps. Steam bubbles, forming in the cross-water tube, where they are more rapidly formed than in any other part of the boiler and following the side of the tubes, are imprisoned in the annular space and accumulate therein, while the convection current rises through the central tube to a point slightly higher than the water level in the boiler. The constantly accumulating steam is taken away by a relief pipe in the annular space and discharged through a contracted nozzle G, just below a constriction in the internal pipe, as from a kind of an ejector. The ascending current of water is deflected by a baffle plate, the annular outlet of which is equal in area to the inner tube ; hence, as soon as a current is created by the combined convection currents, assisted by the ejector action of the steam jet, the syphon action is set up by the combination of the three forces, and draws the water rapidly through these tubes. As the cross water tubes receive the direct impact of the flue-gases, they generate the steam quicker on their inner surface than on the average heating surface of the boiler, and as the steam thus formed can only find its escape by passing through the injector-like arrangement and raising the water from the bottom of the boiler, fresh water of a lower temperature is constantly being drawn across this heating surface—the most important in the boiler—and the water discharged from the upper portions of the dome, after

parting with the steam, circulates round the internal flues to replace the water drawn from the bottom of the boiler through the cross water tubes, and sweeps off the steam bubbles that have formed on the lower convex surfaces of these flues, and causes them to pass up the cross-tubes into the steam-space. This makes the lower halves of the internal flues efficient surfaces for heating the water, which is not the case in boilers without the Circulators. The effect of circulation of the water in promoting absorption of the heat by the water through the plates from the gases is of considerable importance. According to the generally received theories, the greater the difference between the temperature of the gases on the one side of the plates and the water on the other, the greater is the rate of transmission of the heat through the plates. Hence, we should probably find that if the volume of water in the lower half of the boiler was raised 100° by being mixed with the water above the flues, the rate of transmission would be less. The results of all the experiments made, however, show that the efficiency of the boiler is increased, for the steam is raised in a less time and with a less consumption of coal, and this has been further verified by a series of experiments made at a large ironworks in Leeds on a pair of similar boilers heated by the waste gases from the same puddling furnaces, one having Acme Circulators fitted in it and the other not. In this case the gases from the puddling furnaces are taken through two Cornish boilers, and thence to the flue, without being taken round and underneath the boiler, so that any heat obtained by the water at the bottom of the boiler must be due to circulation. This experiment showed that the boiler fitted with the "Acme" Circulators—identical with the one without "Acme" Circulators and fired simultaneously from the same puddling furnaces—showed an increase of temperature of the water at the bottom of the boiler of 70°, and an increased efficiency in raising steam to blowing-off point of 15 % in time. In measuring the quantities of water evaporated per hour an increased evaporation of 18 % was noted. Further experiments have shown a corresponding decrease in the temperature of the gases going away from the boiler, thus confirming the result :—that the circulation of the water inside the boiler had increased the rate of transmission of the heat through the plates.

These results of circulation seem to be on a par with the results observed from the employment of live steam in marine boilers, where theorists assert that the employment of heat to convert water into steam and then to turn steam into the water of the boiler could give no beneficial result. The facts of practice, however, contradict them in some unexplained way. The probability is that perfect circulation, *i.e.*, a perfect freedom for each particle of water which has received its load of heat through the plates to move freely away and to part with its steam in the common steam-space of the boiler and then return freely without meeting any obstruction to the source of heat, viz., the plates in contact with the gases, will enable a very much larger percentage of work to be obtained from boilers of this type than was formerly thought possible. The data upon which these conclusions are based have been collected from over fifty very carefully recorded experiments in actual practice, under varying conditions where the combustion has been from as low as 14 lbs. of coal per square



VERTICAL SECTION OF BOILER SHEWING "ACME" CIRCULATORS.

foot of fire-grate per hour, to more than twice that quantity, and extending over periods varying from one hour to one month, under normal conditions, and under the control and inspection of experts, where every element of difference in the conditions has been noted.

While the exact value of internal circulation in increasing the efficiency of this type of boiler has yet to be determined, enough data have been gathered together to show that it is very considerable, and that where the rate of combustion is high it is of very great importance, and in the near future will cause this type of boiler, which already supplies about 65 per cent. of the steam used in the United Kingdom, to enjoy a still greater amount of public favour.

THE "LANCASTER" STEAM TRAP.

SOME RECENT IMPROVEMENTS.

THE "Lancaster" Steam Trap is already well known in the market, upwards of 60,000 having been sold during the last seventeen years; but of late, considerable improvements have been effected in its working, especially in connection with high pressure steam. As many of our readers know, the speciality of the "Lancaster" Steam Trap consists in the loose disc valve at the orifice of the discharge-pipe in connection with a quick-thread screw motion, worked by the float. The valve is frictionless

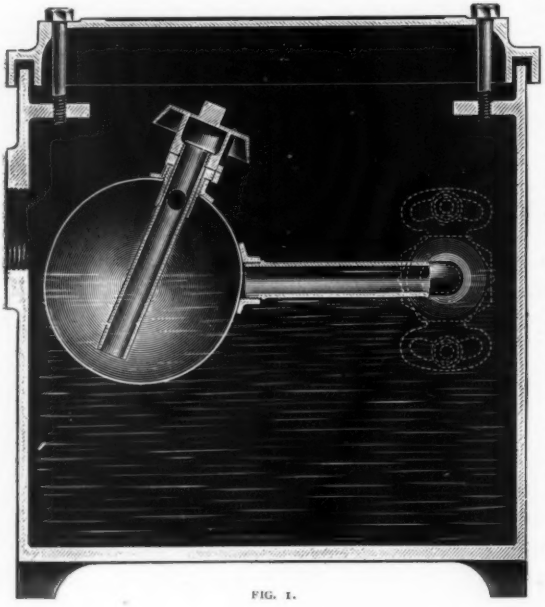


FIG. 1.

in action, and being loose, cannot stick to its seat. It is very prompt in its movements for opening and closing the discharge-pipe, and the working parts are very simple and easily examined. It also acts as a safety valve, as any excessive pressure exerted against the face of the loose disc valve would, by virtue of the quickness of the screw thread, force it open. The chief features of the latest type of this trap will be readily gathered from the annexed description of its action.

We will suppose the ball to have fallen to the bottom of the trap (see fig. 2). The loose valve is then away from the seating, and all the condensed water present flows through the hollow spindle and elbow-pipe into the ball, then up the down-pipe and through the outlet. As long as the condensed water is present, the ball remains down as shown, but the entrance of steam empties the ball by forcing the water up the down-pipe; the ball then becomes buoyant, and rising, rotates the quick-threaded screwed spindle and closes the valve. The ball is then full of steam, which, slowly condensing, allows the water in the trap to flow into the ball through the small hole at the bottom, thus destroying its buoyancy and causing it to fall. When the ball falls, if live steam be present, it will at once rise and close the valve, and allow no steam to escape; should there be condensed water present it will fall, and the trap will remain open till all the condensed water has escaped, but on the entrance of steam it will at once close, and thus the cycle of operations is continued. Its action is similar to a man standing by a wheel valve, and keeping it open as long as condensed water is flowing out, closing it as soon as ever steam appears, slightly opening it again to see if there is any more condensed water; and, if so, keeping it open and allowing all the condensed water to escape, and closing it as soon as ever steam commences to appear, and so on alternately. In connection with steam at very high pressures, it is found that the temperature of the escaping water is often so much above boiling point at atmospheric pressure that a considerable portion of it bursts into steam when it gets into the ball, causing the latter to rise and shut the valve before all the water has passed. To obviate this, a hollow valve or tap is formed in the upper part of the ball, as shown in fig. 1, and by opening this partially or fully the steam can be liberated and the water passed off at any temperature up to that of the steam from which it is drained. Although this improvement has only quite recently been introduced, it has already caused a rapid increase in the number of traps sold for high pressure duty.

The Lancaster Metallic Packings have not been before the public so long as the

steam trap, but have already been supplied to the British and foreign navies, and many of the leading engineers in this and other countries. As will be seen from figs. 3 and 4,

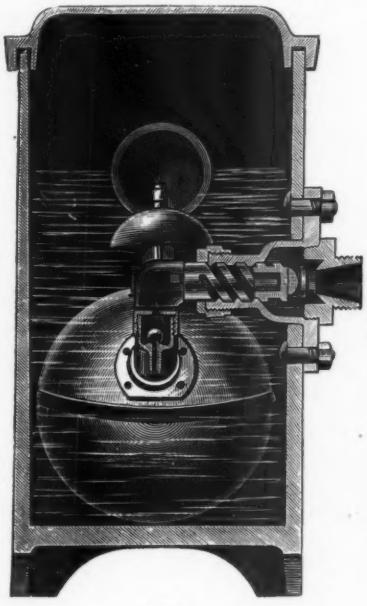


FIG. 2.

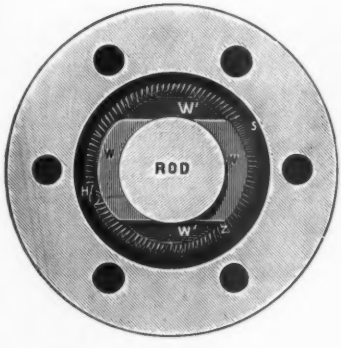


FIG. 3.

the packing consists of metallic rings in segments W, which are pressed to the rod by the encircling springs Z. The latter are readily adjusted to compensate for wear by screwing them together at S. It is claimed that they have fewer parts, are more easily fixed than any other metallic packing, and are thus better adapted for working in

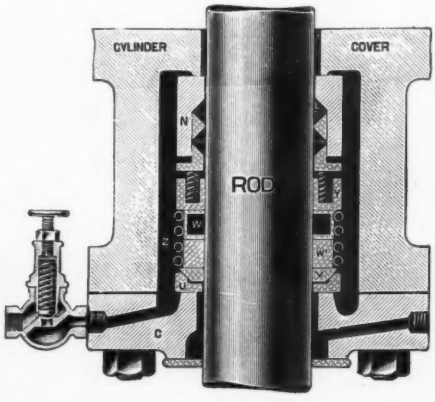


FIG. 4.

enclosed positions. The latest improvement in these packings consists in excluding the steam pressure from the casing in which the packings work, by fitting an auxiliary packing in the same casing which fits against the cylinder end of same, while the ordinary packings fit against the outer end, as shown in fig. 5. A relief valve is then fitted to the casing so as to pass off any excess of steam passing the auxiliary packings. In this manner it is possible to apply the packings

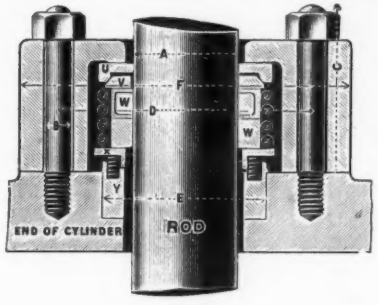


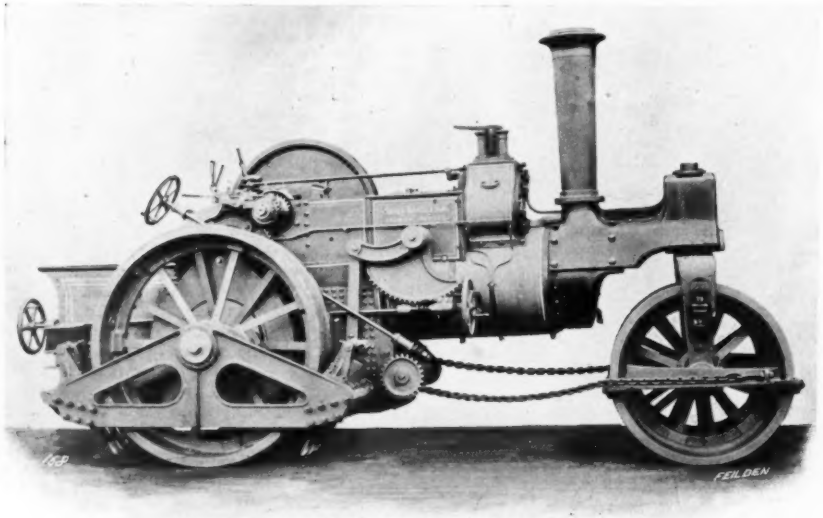
FIG. 5.

to a cylinder working at 200 or 300 lbs. per square inch, and not have more than 30 lbs. per square inch in the casing, thus causing the packings W to be relieved of any excessive pressure, and enormously increasing their durability.

SOME NEW ENGINES AT THE "ROYAL" SHOW.

THE days when every succeeding "Royal" Show presented its fresh series of novelties in the implement yard seem to be passed, and the visitor to the great annual meeting has to content himself with the examination of modifications in the structural details of existing types of machinery rather than with investigating the merits of absolutely new mechanisms still in their early probation. This was especially noticeable this year, and, while the implement yard at Maidstone was as comprehensive as usual, and the collection fully up to a high average "Royal" standard, there were few exhibits which could justify any substantial claim to novelty. The fact that this entry, that or the other, was specified in the official catalogue as a "new implement," signified little, for the "Royal" authorities are generously elastic in their definition of novelty.

As might have been anticipated, there were few engines shown which could claim distinction in this particular. An exception might be made in the case of the transport steam motor vans exhibited by Messrs. John Ellis & Co., Limited, of Maidstone. This van is intended for the transport of fruit or other produce, and will carry a three-ton load on ordinary roads at a speed of from four to eight miles an hour. In this type of motor vehicle the boiler is vertical, and is placed at the front end, near the brake and steering wheel. The engine is placed beneath the floor, and motion is communicated to the driving wheels by means of suitable gearing arranged on principles which exhibit no undue complexity of mechanism. The working platform and the boiler have a canopy overhead, through which the chimney projects. The van itself is built on lines that give rigidity and strength to the entire vehicle.

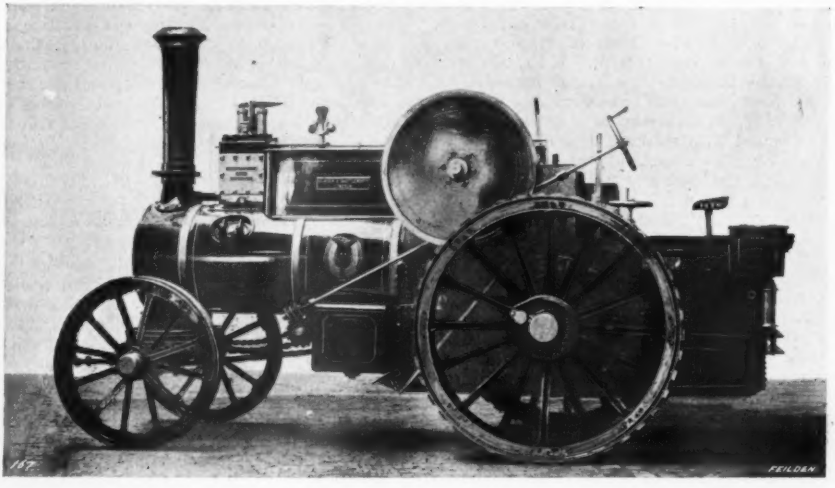


IMPROVED ROAD ROLLER AND SCARIFIER BY MESSRS. CHARLES BURRELL AND SONS.

Another exhibit of a somewhat similar description was the steam larry of Messrs. Mann & Charlesworth. In this case a locomotive type of boiler is employed, and the engine, built on the compound principle, is placed on a feed water tank beneath the floor of the vehicle. The flat larry is entirely distinct from the engine and boiler portion, being supported on a pair of wrought iron wheels, placed in the centre of the cart, so that it can be tilted for discharging certain

kinds of load. When thus tilted, access can readily be had to the engine for examination or adjustment. The wheels of the larry are the same diameter as the driving wheels, and the former may, when desired, be coupled to the latter, becoming then to all intents and purposes driving wheels also. Two travelling speeds are provided, and no pitch chains are used in transmitting motion from the engine to the driving axle.

In portable engines there was a novelty shown at the stand of Messrs. Marshall, Sons & Co., Ltd., of Gainsborough. There was nothing, however, especially striking about the general design or the working details, but it was noteworthy that the engine was going backwards or forwards. Another previous objection is removed by the tyres always following the wheels, and both sets are pulled into their work ; thus the rolling of the roadwork after it has been broken up is avoided. The tyres also follow the road-wheel more closely than is usual, and the hind rollers really serve the purposes of guide rollers in regulating the depth to which the tyres shall enter the ground. The scarifier is attached in this case to the axle of the engine, and need not be removed when out of action, as its presence in no way interferes with the manipulation of the engine when being used for other work. Another point about these road-rollers which is



MESSRS. CLAYTON AND SHUTTLEWORTH'S NEW ROAD LOCOMOTIVE FOR CONTINUOUS HAULAGE WORK.

arranged with these carriages to the crank shaft, and that the cylinder, the brackets for the guide bars, and the crank shaft carriages were mounted on steel seatings rivetted to the boiler, a practice which is now becoming very generally adopted by makers.

There were five steam road rollers in evidence at the Show, three of these being fitted with scarifiers for tearing up old roads by power instead of by picks and manual labour. Messrs. Charles Burrell & Son's patent road roller and scarifier has recently undergone some modifications in design, and as the apparatus now presents itself it is an admirable piece of machinery. The scarifier will now work with equal efficiency, whether

worthy of special note, is the fact that the patent roller fork arrangement employed has a very deep bearing, thus obviating the defect of causing the pressure to be taken by the lower edge of the fork stem only. The entire apparatus is built on very strong and powerful lines, and, as our illustration shows, presents an excellent appearance.

Closely allied in some particulars to these scarifiers was the new form of digger attached by the Darley Land Syndicate, Ltd., to a traction engine made by Messrs. Ransomes, Sims & Jefferies, Ltd., of Ipswich. Since some dozen years ago or so the original Darley digger made its *debût* at a "Royal" show, no such gathering would be

seemingly complete without some sort of digging machine, and the implement yard at Maidstone this year was no exception to the rule.

One would almost think that in the dominating details of its construction the traction engine, as we have come to know it during recent years, has arrived at finality as a fixed entity in engineering practice. A visit to the Show served rather to confirm this impression than otherwise, but yet not quite. That is to say, there was the usual comprehensive show of the best individualities in traction engines now in the market, together with a happily diminishing number of those types which have ceased to commend themselves to the discriminating practical mind.

In this connection the exhibit of Messrs. Clayton & Shuttleworth, of Lincoln, presented features of interest. It included two powerful traction engines of new design. Of these one was intended to drive a threshing machine, and also draw the apparatus from farm to farm in the ordinary way. Constructed on evidently careful lines, this engine impressed one favourably, but there was less in the shape of structural or detail novelty about it than was shown in the case of another exhibit of the same description, also made by the Stamp End firm. This was a new road locomotive especially built for continuous haulage work. Its makers have wisely kept in view the adaptability of the engine to other functions than those of traction, which last is by no means the Alpha and Omega of motors of this description. Accordingly, for the purposes of builders, contractors, and brickmakers, to particularise these as examples, whose normal requirements demand the employment of a powerfully equipped machine for heavy haulage on common roads, this engine, which we illustrate herewith, will commend itself. The steel gearing employed, which is of a strength and width somewhat unusual even in powerful road locomotives, is well protected from dust. The shafts and axles are also made of steel of convincingly strong proportions, and in order to promote the tractive powers of the locomotive the driving wheels are made large in diameter and width, the leading wheels being also, it seems to us, correspondingly increased in size.

A close examination further shows that underneath the boiler barrel a feed tank is provided, while the fore and hind tanks are provided with a pipe connection, a cock in the pipe, which reaches from the foot-plate, enabling the engine driver to shut off the communication between the tanks while the locomotive is going up or down steep hills, an expedient calculated to prevent loss of water when the tanks are full. As the average traction engine is still a bogey in the eyes of the unsophisticated horse, the designers have been careful in this case to provide plates on each side of the engine to obscure from view the working parts, and with the same intention the fly-wheel is plated. For the rest it may be said that this engine is supplied with such accessories as a water lifter and hose pump, an injector as well as the customary feed pump, and a pair of lamps, fitted, of course, with slides to enable the light to be instantly shut off in accordance with the requirements of recent legislation on the subject of steam road locomotion. In other particulars the details are in accordance with the best practice in road locomotive construction, of which Messrs. Clayton & Shuttleworth are eminent exponents. Having said that, we have said sufficient probably to justify the inclusion of this new engine amongst the productions which find an illustrated record in our earliest pages.

EXPERIMENTS IN EXPLOSIVES.

GREAT progress has been made in the manufacture of explosives in the direction of gaining power. Something more, however, is needed in the direction of controlling the explosion, so that it shall always occur when wanted. Experiments were made recently on Sandy Hook proving ground, before the United States Board of Ordnance and Fortification, in two new methods of throwing high explosives from ordinary guns. A shell, invented by Mr. W. S. Isham, containing 113 lb. of blasting gelatine, was discharged from a modern 12-inch breechloading rifle, with an ordinary service charge of brown prismatic powder, and did not explode. The projectile used weighed 1,031 lb., and the propelling agent was 450 lb. of brown powder. Experts consider the tests demonstrated that high explosives can be fired from coast defence guns with safety but before the shells are accepted they will be subjected to more severe tests. Thorite, a new explosive invented by Dr. Tuttle, of Tacoma, also successfully stood severe tests. It was hammered on an anvil, and ground between steel plates without exploding. A red-hot iron was plunged into a can of thorite, but it merely ignited the particles that touched the iron. A shell loaded with 12 lb. of thorite was discharged from an 8-in. gun, and passed through a harveyised steel plate 4½ in. thick without exploding.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

CIVIL AND MECHANICAL ENGINEERING.

British Machine Guns for America.—It is gratifying to note that the interchange of machinery between Great Britain and the United States is not all one way. We hear that Messrs. Vickers, Sons, & Maxim have manufactured a new 6-inch quick-firing breech-screw gun for the United States Navy. Judging by the recent trials of this gun, it will fire a 100-lb. projectile with a velocity of 2,873 ft. per second, and a striking energy which will perforate 17-in. of steel armour.

All is not of the best from America.—Messrs. Flint, Eddy & Co., of Buenos Ayres, have handed to the Argentine Government the sum of 20,000 dollars for account of defective machinery and rolling stock supplied by the firm of Jackson, Sharp & Co. of the United States, for whom they acted as agents. According to the contract the Government had an inspector in the United States who ordered certain alterations, and did not examine the goods before they were shipped. The manufacturers refused to refund the money, as they said that the defects were due to the Government inspector, but the agents, not desiring to appear in a bad light with Government, have paid the difference for the defects not due to the inspector's order.

A New Water Softener (W. J. Baker's patent) is being introduced by Messrs. D. Bridge & Co., Salford, Manchester. In this apparatus the hard or dirty water is blown into the upper part of the heater in spray, and is there met by steam in such proportion that the water boils, and at this stage a small quantity of calcide solution is introduced. The heated water and calcide pass down over several concave and conical surfaces in the heater, becoming thoroughly mixed, and the lime with other impurities at once separates from the liquid in heavy insoluble particles, the greater part of which at once falls to the bottom of the first of three compartments of a depositing tank. The clear softened water from the top of the first compartment then passes to the bottom of the second, and from that to the third, whence it finally passes out through a suction pipe to the boiler feed pump, storage tanks, reservoirs, or wherever required.

Iron and Steel in the Construction of Roadways.—In the United States iron and steel are now regularly employed in the foundations and superstructure of almost all kinds of new buildings. A new application, of which large expectations have been formed, is the construction of roadways with a view to greater durability of the road and the reduction of the power needed to move a vehicle. The Department of Agriculture at Washington has had this matter under consideration, and has reported that the cost of the laying down and purchase of steel track on common roads might be given at 3,000 dols., or £600 per mile. In Great Britain there are now over 30,000 miles of common roads, and it is manifest that if steel track were to be generally adopted it would conceivably lead to a total outlay of 18 millions sterling, of which, on the basis of the American Agricultural Department, one half would be expended on the purchase of steel alone.

Usk Navigation Schemes.—The Newport (Mon.) Harbour Commissioners propose to erect a training wall and public wharf at Powder-house point, on the river Usk. It is suggested that the commissioners should bring forward the line of river wall sufficiently to erect a high level coal shipping place for Western Valleys coal, which could be shipped without incurring the dock charge of $1\frac{5}{10}d$. The accomplishing of this would lead indirectly to the abolishing of the level crossing at the end of Commercial Road, Newport, as for the purposes of the high level shipment the railway would be raised and would be carried over the road at this point by a bridge. The shoal or island in front of the old dock would be dredged away. The scheme would give the commissioners an opportunity of making places in the river for the loading and discharging of steamers at a lower cost than any other dock in the Bristol Channel or river-port in the kingdom. The schemes of improvement would correct the undue width of the river and consequent siltation at the bends below each of the docks, and concurrently present the river with facilities for loading therein, and avoiding the present necessity for going elsewhere.

Great Opening for Manufacture of Structural Iron and Steel Work.—Apart from the railway and shipbuilding requirements of the

world, one of the largest and most promising fields open in the future is that of the manufacture of iron or steel employed in the erection of buildings of different kinds, galvanised iron, beams, girders, pillars, joists, flooring, &c. In Great Britain, at least half-a-dozen works have within the last few years taken up the manufacture of girders in order to meet the home demands. These works have a capacity of some 200,000 tons a year, in addition to which Great Britain imports about 80,000 tons of similar material. There is also an annual export of 230,000 to 240,000 tons of galvanised sheets, and a probable home consumption approaching 100,000 tons additional. These items, unitedly, make up a total exceeding 600,000 tons a year, which is an advance of probably 200 per cent. on the corresponding figures of twenty years ago. In the United States the advance has been even more remarkable. There the total production of structural material in 1898 exceeded 700,000 tons, and in 1899 it is expected to exceed 800,000 tons, which will have been an advance of about 200 per cent. within ten years.

A New Smoke-Preventing Furnace Door, applicable to any furnace working with natural draught, has been designed by Mr. James Lethem, of Cheetham, Manchester. In this arrangement the air supply is intimately mingled with the smoke-gases arising from every part of the grate. The door delivers a supply of air at the front of the furnace, discharging it to right and left as well as centrally in the furnace, so that the air is proportionately spread across the entire length of the grate. The natural suction towards the bridge then carries the air supply lengthways over the whole surface of the grate, and the hydrocarbon gases, wherever arising, consequently receive, as soon as formed, and when at their hottest, the necessary complement of oxygen, with the result that smoke is either not made at all, or only to a slight extent. The Lethem door also enables a considerable economy in fuel consumption to be secured. It is made in two forms—semi-automatic and automatic. In the former, when the door is shut after firing, the valves with which it is provided open automatically and independently of the action of the fireman. In the automatic form, the slots are both opened and closed automatically, being opened on the shutting of the door, and held fully open for some pre-determined time, after which they are gradually closed. The Lethem door has recently been adopted with very satisfactory results by several well-known firms in the Manchester district.

New American Type of Engine.—A new type of engine has been completed in Philadelphia, after an expenditure of $90,000 in cash and ten years of incessant labour of brain and hands. It has demonstrated, according to its projectors, under the most severe tests, that it can save 50 per cent. of the present mechanical energies; or, in other words, it can produce 50 per cent. more power with the same amount of fuel than the best engine of the present under exactly similar conditions. The energizer is composed of four fly-wheels, which are rotated by means of four small engines of five horse power each, and the total load of electric lights that can be carried by these four engines, without the energizer, placing them under the most advantageous circumstances, is one hundred and eighty incandescent sixteen-candle power lights at one hundred and ten volts. By means of this invention and the use of the energizer the gain in lights is ninety-one sixteen-candle lamps at a voltage of one hundred and ten, which is fifty per cent. gain. A brief description of the machine shows that there is a shaft eighteen feet long placed upon three journals, and upon the shaft are the four fly-wheels, which are mounted "loose" upon the shaft and only connected to it by clutches, which are worked by an ingenious automatic device. One wheel at a time is taken up and works the shaft; while one wheel is doing the work the others are gathering momentum for their regular turns. Under the old system, which is everywhere in use to-day, the wheel is loaded, or has the resistance of the work to overcome, and even in that case the fly-wheel has to accelerate so as to give sufficient momentum to carry the engine and its load over the dead centres. Exactly what this great saving in fuel will accomplish cannot be conjectured.

MARINE ENGINEERING AND SHIPBUILDING.

New Anglo-Russian Steamship Line.—Recent Odessa advices state that, according to the *Odesskiya Novosti*, the Committee of the Odessa Bourse has been notified by the Department of Commerce and Manufactures that M. de Witte, the Minister of Finance, is willing to subsidise a line of fast steamers between Russia and Great Britain, it being compulsory for the vessels to be provided with refrigerators for preserving poultry, game, beef, mutton, butter, and Russian agricultural produce generally. The steamers are to have a minimum speed of ten knots. Presumably, this is one of the first fruits of the new Anglo-Russian *entente cordiale*.

New Atlantic Steamers.—The American Line are building four new steamers for the Atlantic trade, two at Clydebank and two at Messrs. Cramp's yard, Philadelphia. The first will be ready about September or October next year, and the others will follow at about two months' intervals. They are 560 ft. long, 60 ft. beam, and 42 ft. deep, of about 13,000 tons gross register, and when fully loaded will have a displacement of 20,000 tons. They will be fitted with twin screws, the engines will have 10,000 horse-power, and a speed in actual service of seventeen knots. The vessels are intended for the Red Star Line running between New York and Antwerp, calling at Southampton. They will be fitted in all departments for first, second, and third-class passengers with

every possible improvement, including the system of mechanical ventilation adopted on the St. Louis and St. Paul.

Launch of a U.S. Pioneer Torpedo Boat.—The *Stringham*, the largest and costliest torpedo-boat yet built for the United States Navy, was launched from the yards of the Harlan and Hollingsworth Company, Wilmington, Del., recently. She will be the pioneer ocean-going vessel of her class, and her guaranteed maintained speed will be 30 knots. The *Stringham's* keel was laid on March 21, 1898. Her length is 225 ft.; breadth, 22 ft.; mean draught, 6 ft. 6 in.; and displacement, 340 tons. This is 70 tons larger than the *Farragut*, twice as great as any other American torpedo-boat built or building, and is within 60 tons of the weight of some of the destroyers. Two vertical triple-expansion engines driving twin screws will develop 7,200 horse-power when forcing the boat at her maximum speed. This power is greater by 1,500 than that of the *Farragut* or any of her class, and equals that of most destroyers. The normal coal supply is 35 tons, but the bunker capacity of the *Stringham* is 120 tons, and with this she will cruise over 1,000 knots. The *Stringham* will carry two 18-in. Whitehead torpedo-tubes and seven 6-pounder semi-automatic guns. Her crew will consist of four officers and twenty-eight men.

The Floating of a New Cruiser.—The new third-class cruiser *Pioneer* was successfully floated on the 28th May at Chatham. Her keel was laid on the 16th December, 1897, but the length of time between that preliminary and her floating is accounted for by circumstances other than are connected with her construction. H.M.S. *Pioneer* is a sister ship to the *Pandora*, building at Portsmouth, as also to the *Psyche*, which is now serving on the North American station, and which was built at Devonport; all three having been designed by Sir W. H. White, Director of Naval Construction. She has a length of 305ft., which is 5ft. longer than the *Pactolus* class, and her extreme breadth is 37ft. Her draught of water forward is 12ft., and aft 15ft. She has a displacement of 2,215 tons. The new cruiser is fitted with twin screw engines in separate engine rooms, capable of indicating 7,000 horse power, and giving a speed of 20 knots per hour. Steam will be generated by eight watertube boilers of the Thorneycroft type. The whole of the propelling machinery has been supplied by the Fairfield Company, Glasgow. The *Pioneer* is armoured to some extent, the conning tower being plated with 3in. nickel steel, whilst vital parts are protected by a steel deck. The armament is of the latest type, and consists of eight 4in. quick-firing guns, eight 3-pounder Hotchkiss guns, and three 45in. Maxims, and she will also be equipped with torpedoes. The boilers, engines, auxiliary machinery and guns are on board, and the funnels and masts of the ship would also have been in position had the height of the roof of the shed permitted. Her floating out weight was 1,500 tons. The *Pioneer* is to be completed ready for sea by the 31st of August.

Activity in German Shipbuilding Yards.—The launch of the *Kaiser Wilhelm der Grosse* leads "Stahl und Eisen" to dwell with pride on recent German shipbuilding progress. After recounting the satisfactory condition of the Germania Company's business, now in the hands of the great Krupp house, it describes a Brazilian combined protected cruiser and torpedo-destroyer, the *Tamoyo*, barely 1,000 tons, and destined to do 22 knots. The next yard for review is the Vulcan of Stettin, where the first Japanese warship order to Germany is being executed. This yard, which is building a series of great trans-oceanic boats, including the *Deutscher*, which is to race and beat the fastest vessels afloat, is particularly proud of having got a Japanese order past the English.

But the Schickau Company's yard leads the way for wonders. It is building armoured cruisers for Germany and Russia, and the 35-knot Chinese torpedo-destroyers are its work. They are now *en route* from Colombo to China, having completed the distance, Port Said to Colombo, 3,550 sea miles, without stopping at an intermediate station, still with a fair quantity of coal on board. There was no damage to hull or machinery. Nowhere before has such a result been achieved. This Company has received an order from the German Government for twelve destroyers, from the Russian Government for four, and from the Japanese Government for six.

The First-class Battleship Vengeance was launched from the yard of Messrs. Vickers, Sons, and Maxim, at Barrow, on Tuesday, the 25th July. The *Vengeance* is of the Canopus class, her length between perpendiculars being 390 ft. and her beam 74 ft. At a mean draught of 26 ft. her displacement will be 12,950 tons. Her coal capacity is 1900 tons. Her engines are triple-expansion, 30 in., 49 in., and 80 in. respectively, with a stroke of 4 ft. 3 in. The screws are 17 ft. in diameter. She is fitted with twenty Belleville boilers, which will be pressed to 300 lb. on the square inch. The indicated horse-power is estimated at 13,500, which is calculated to drive the ship at 18¼ knots.

Facts from "Lloyd's."—Nothing more indicative of the shipping and shipbuilding industries of the United Kingdom could be studied than the facts and figures in the new volume of *Lloyd's Register Book*. It appears that of the whole world's tonnage of 27,673,528 tons the United Kingdom and the Colonies own no less than 13,988,508 tons, or more than one-half. Next in order, but a very long way off, comes America with less than 2,500,000 tons, and Germany makes a close third. The following table shows the relative importance

of the countries owning more than 500,000 tons as regards merchant shipping :—

	Tons.
United Kingdom	12,926,924
Colonies	1,061,584
Total British tonnage	13,988,508
United States	2,465,387
Germany	2,453,334
Norway	1,694,230
France	1,242,091
Italy	875,851
Russia	643,527
Spain	608,885
Sweden	605,991
Japan	533,381
Denmark	511,958

The above figures apply to sailing ships as well as steamers, but steam tonnage has about three times the efficiency of sailing ships. Our steamers represent 11,719,247 tons altogether, while those of all other countries combined amount to about 9,000,000 tons. Germany comes next with nearly 2,000,000 tons, America being third with less than 1,250,000 tons.

Coming now more particularly to shipbuilding, we find that the new tonnage launched in this country amounted to 1,295,415. Then we built 13,026 tons for France, 79,620 tons for Germany, and 50,516 tons for Norway, and sold 600,000 tons to foreigners. The following table indicates the output of all countries whose tonnage runs into five figures :—

Country.	Vessels.	Tonnage.
United Kingdom	690	1,303,894
America	140	169,196
Germany	83	136,186
France	41	53,483
Italy	20	26,806
Norway	29	23,586
Japan	85	22,412
Holland and Belgium	28	19,862
Denmark	20	10,529

ELECTRICAL WORK.

Owing to the high price of copper, the imperial postal authorities of Germany propose to replace it for telephonic purposes with aluminium wire, or iron wire coated with copper. They will use simple iron wire for the telegraphs. So says the *Electrotechmische Zeitung.*

Aluminium *v.* **Copper.**—In America, copper is rapidly giving way to aluminium as an electricity conductor. The inferiority of aluminium is made up for by increased thickness of wire. A set-off to this objection is its greater lightness and tensile strength, which latter quality will effect a saving in telegraph posts.

In the Electricity Accumulators Competition opened in Paris on June 1st, under the auspices of the Automobile Club, only two English houses are entered amongst 21. Those are John Garfield Hathaway, London, and W. Pope & Son, Slough. The closing of the Automobile Club, for political reasons, did not prevent the tests proceeding, and results will be duly reported.

The First Electrical Railway in Belgium is near completion, and will be shortly opened. It runs from Mons to Flenu, about 12 kilometres, and will serve a population of some 70,000. It is a single line on the trolley system. The generating station is completed. The train will consist of a motor and two passenger carriages. This will be the first blow to steam traction in the country.

A Big American Enterprise for Manchester.—The Westinghouse Electric Company of the United States is, according to the *Central News*, about to construct workshops in Manchester, practically duplicating their Pittsburg establishment, and capable of employing five thousand men. Lord Kelvin will be the electrical adviser of the company in this country, and Mr. George Westinghouse, the famous inventor of the air brake, will be directly associated with the enterprise. One hundred acres of land have been acquired on the Trafford Park Estate, near Manchester, forty acres of which will be occupied by the new premises. The works, although laid out on American pl ns, with the newest type of American machinery, will be backed by a million and a half of British capital, and will employ British labour.

New Insulating Material.—Another new insulating material is coming rapidly into extended use throughout Europe. It is known as iron felt, and is made at the Aldershof Works, near Berlin. This felt, it is said, consists essentially of long and strong woollen fibres, impregnated with a by-product of petroleum, and then coated (with a certain amount of penetration) by a gelatine rendered insoluble), and also (alternatively or in addition) with india-rubber, afterwards vulcanised, After being subjected to considerable pressure. the iron felt assumes the form of plates, measuring 20 square centimetres (2 square feet 22 square inches) and upwards, with a thickness varying from 1 to 5 centimetres ($\frac{13}{16}$ inch to 2 inches). These plates are very elastic, being practically imperishable, while they will stand a pressure of 1,158 kilograms per square centimetre (20,736 pounds per square inch), and their surface is so hard as not to be cut by the sharp edges of bolt heads or of iron girders.

Utility *v.* **Natural Beauty.**—A commencement was made last year towards utilising the considerable water power of the Nice district for electrical purposes. A company was formed which at once took in hand the Var, at the

point called "La Mescla," where it is confined in a narrow gorge. A tunnel was pierced through the solid rock of some 600 metres in length into the Vallon de Fenouillet, where a large reservoir has been formed, and whence the considerable fall thus obtained is about to be utilised by the Electric Tramways Company, which is literally taking possession of the whole littoral, to the great disgust of this aristocratic neighbourhood, and more especially of Cannes, where but one road exists to join the east and west portions of the place, and that a narrow one at the best. Protests, says a consular report, are rife, but have so far proved useless, as far as Cannes is concerned, and at Nice a great effort is being made to save the beautiful boulevards, shaded by fine trees, and bordered by handsome houses, from this invasion.

Electricity in Manchester.—According to the annual report of the Electricity Committee of the Manchester Corporation, it appears that rapid advances are being made in the utilisation of electricity in that city. During the year ended 31st March last, there was an increase of 44 per cent. in the output of electricity from the works, amounting to 1,722,255 units. The consumers numbered 2,570, being an increase of 515 during the year. Mains laid measure 74 miles 217 yds., an increase of 28 miles in the year. The gross revenue amounted to £71,941, and the expenditure to £34,350, showing a gross profit of £37,590, out of which £20,402 went to meet interest on mortgage debt, and as contribution to sinking fund, leaving a surplus or net profit of £17,188. This has been appropriated by payment to the city fund in aid of rates of £12,000, and to the reserve fund £3,188, carrying forward £2,000 to next year's account. The total capital expenditure on the undertaking is £493,716, and application has been made to the Local Government Board for sanction to raise an additional sum of £500,000 for extensions.

RAILWAY WORK.

The Locomotive and Railway Carriage Manufacturers, not only in Bavaria but in all Germany, are so overwhelmed with urgent orders for a long time to come that the Bavarian State Railways have the greatest difficulty in obtaining the rolling stock they require, and last year an order for 500 goods wagons was placed with a Belgian firm.

A Project for a New Light Railway is on foot from Andoversford, near Cheltenham, passing through Burford to Witney, Oxon. A syndicate has been formed for the construction of the line, and an application will be made immediately to the Light Railway Commissioners in regard to the project. Lord Sherborne, Mr. R. H. Hurst, and Mr. M. E. Rhys Wingfield, three of the directors, own nearly half of the land along the proposed route, and they have agreed to take the purchase-money for the land required in shares of the company.

American Steel Rails for Siberia and China.—Another sign of American activity is that the Carnegie Steel Company has signed a contract with the Russian Government to deliver 180,000 tons of steel rails within the next twenty-six months. The price paid per ton has not been authoritatively stated, but experts are guessing that the figure is somewhere between £5 and £5 10s. per ton. It is understood that these rails are to be used in the extensive railroad projects of the Russian Government in Siberia and China. On the basis of 70 lb. per yard, this quantity of rails would lay more than 1,400 miles of track.

Railway Travelling de Luxe.—Satisfied, apparently, with their recent experiment in running buffet cars between Manchester, Sheffield, and London, the Great Central Railway are now attaching buffet cars to three trains during the day from Marylebone to Manchester, and to two from Sheffield to London. Another improvement is Sunday dining-car trains, the 5 p.m. from London containing first and third class dining cars, and the 6.42 p.m. from Sheffield for the South having similar conveniences. This enterprise and public spirited policy may be trusted to result in a substantial measure of public appreciation.

Progress in Light Railways.—As showing how the extension of light railway facilities is favoured by the public, the list of applications made to the Light Railway Commissioners during May last numbered forty. These included one dealing with level crossings on a line already authorised, covering 409¾ miles, of which 25 are to be on the standard 4ft. 8½in. gauge, 12 on the 3ft. 6in. gauge, one on the 4ft. gauge, and one on 2ft. 6in. gauge. Nineteen of the lines, with an aggregate of 148 miles, are to be worked by electricity; 18, with 240¾ miles, by steam; and 2, with 21 miles, by motive power described as "mechanical."

A New System of Compounding the Cylinders of Locomotives has been devised and put into successful practical operation by Mr. John Player, superintendent of motive power of the Atchison, Topeka, and Santa Fé Railroad. The cylinders are in two sets combined with half saddles, and attached to a long smoke-box room, with sufficient space between them to admit of taking out the rear or low-pressure piston without removing the high-pressure cylinder, the piston-rods being spliced for this purpose. Piston valves are used, and an interesting feature of their construction is the absence of packing rings. The arrangement of the valve-rods, whereby the cut-off on the high-pressure cylinder may be changed by a simple

adjustment without interfering with that of the low-pressure cylinder, is novel. The valve stem for the low-pressure cylinder is hollow, and that of the high-pressure cylinder passes through it. The valve-rods have separate attachments to the upper rocker arm, and by changing the point of connection of that for the high-pressure valve its travel is altered, and the cut-off may be made suitable for the special conditions under which the engine is to work. This arrangement of tandem cylinders avoids the extremely large steam clearances of some former designs of tandem compounds.

MINING.

The State of Bahia is said to be the sole seat of the carbon industry. The carbons have been found for years, but there has been no market until the commencement of the present decade, when on account of their hardness they were sought by makers of so-called diamond drills. The carbons are found in a kind of gravel called *cascalho*, and this occurs in the river bed beneath the silt and on top of a stratum of clay; in the mountains they are found beneath a stratum of rock and above the same stratum of clay, and in the surrounding country beneath several strata of earth.

Indian Gold Production.—Figures are now available which enable one to glance at the progressive character of the production of the gold mines in Mysore, India, the principal gold-yielding district of our Eastern Empire. The following tabulated statement gives the statistics of production for the first six months of this year, and for the years 1894 to 1898 inclusive:—

1894	209,729 ounces
1895	249,355 ,,
1896	321,878 ,,
1897	389,779 ,,
1898	415,147 ,,
1899 (Six Months)	206,223 ,,

It will be seen that the progression is steady, last year holding the record with a substantial advance over any preceding twelve months. The first six months of last year yielded a total of 207,163 ozs., against 206,223 ozs. for the corresponding period this year, but it has to be remembered that May last year made the record monthly yield of 38,471 ozs. (which is very nearly approached by June this year, which takes the second highest place with 36,470 ozs.), and but for this fact the Mysore yield for the first six months of 1899 would be the largest in the annals of latter-day Indian gold mining. These figures, in view of the much talked of prospective "boom" in Indian gold mining, are full of interest.

Iron Ore in Kent.—A discovery of iron ore, which may yet prove to be of payable industrial value, has been made at Dover. It appears that when the coal boring was commenced at Dover about six or eight years ago by Mr. F. Brady on the site of the old Channel Tunnel works and the present Kent Colliery works, there were indications in the bores drawn of the presence of iron ore in the strata between 500 ft. and 600 ft. from the surface. The indications have proved correct. In the course of sinking the No. 2 shaft, a bed of valuable oolitic iron ore has been struck at a depth of rather less than 600 ft. The seam proves to be no less than 12 ft. thick, and probably extends over a great area, the quantity being, it is said, evidently practically unlimited. The diameter of the shaft is 20 ft., and the quantity brought to the surface in passing through the 12 ft. amounted to about 350 tons. Samples of the ore have been submitted to analysis with highly satisfactory results, a washed sample of the ore yielding 45·8 per cent. of iron. A washed sample of the ore tested at the works yielded between 50 and 60 per cent. of iron. The analysis shows the ore to be free from sulphur and phosphorus, and to be of much richer quality than the Wealden ironstone worked in Kent and Sussex a century ago. The ironstone presents very singular physical characters. It is composed of dark brown shining grains of hydrated oxide of iron, like millet seed, embedded in a crystalline base partly of calcium carbonate and partly of iron carbonate. It is quite within the range of reasonable geological speculation that very rich deposits of iron ore may yet be opened up in Kent.

Mineral Production of Kansas.—According to the report of the University Geological Survey of Kansas, the total value of the mineral industry of that State in 1898, including the smelting industry, reached the enormous sum of $27,169,900·33, more than five millions sterling. This is greater than the corresponding figures for 1897, which were $26,990,543·92. During 1898 some of the mining industries were decidedly larger than for 1897, while a few of them suffered a slight decrease. The following table gives the matter in a condensed form:

Non-Metallic Products.

	Values.
Coal	$4,193,159.70
Salt	481,354.23
Clay goods	390,630.00
Gypsum	129,651.76
Limestone	180,000.00
Sandstone	22,000.00
Natural gas	188,120.75
Oil, refined	176,000.00
Hydraulic cement	60,800.00
Lime (estimated)	65,000.00
Sand (estimated)	50,000.00
Total	$5,937,716.44

Metallic Products.

Zinc ore	$3,822,768.68
Lead ore	463,464.84
Total	$4,286,227.52

Smelting Products.

Zinc smelting	$3,648,715.57
Lead smelting	170,277.01
Argentine	13,124,963'79
Total	$16,943,956.37
Grand Total.....	$27,169,900.33

The value of the coal output was over $700,000 greater for 1898 than for 1897; there was an increase in the value of salt output of $64,700; an increase in clay goods, principally brick, of over $125,000; a decrease in gypsum and gypsum cement plasters of about $23,000; an increase in petroleum and refined oil of nearly $100,000; an increase in natural gas of about $25,000; while hydraulic cement, building stone, lime, and sand about held their own. There was an increase of about 35,000,000 lbs. of zinc ore over the figures published in the annual report for 1897, and a decrease of about 18,000,000 lbs. of lead ore. The higher price, however, for both lead and zinc ores made the aggregate value of the combined ores at the mines greater by nearly $100,000. During the latter part of 1898, the price of spelter advanced very rapidly, much more rapidly, in fact, than the price of zinc ore, so that the value of the metallic contents of the zinc ore shows a greater gain. For 1897, the value of the metallic contents of the lead and zinc ores was $3,710,647.17, while for 1898 it was $4,286,277.52, a gain of $575,580.35. The smelting industry increased more rapidly than the production of ores, due largely to the great activity of zinc smelting in the natural gas region.

CHEMICAL INDUSTRIES.

France still leads.—The Parisian Journal *Aluminium*, 20th June, says that the Buda-Pesth Acetylene Exhibition has demonstrated, at least, one thing, viz., that France leads in that industry. There are already twenty carbide manufactories in France, mostly driven by water. In aluminium and electricity, too, says this paper, France triumphs, and the Exhibition of 1900 is to make up to France in the matter of industrial honours for all her recent humiliations in other spheres.

Deodorising and Protecting Carbide of Calcium.—M. le Roy, chemist of the town of Rouen, has invented a process for deodorizing and protecting carbide of calcium. It is well known that in damp air the carbide decomposes, giving off evil-smelling fumes of acetylene, and causing a certain amount of danger of fire. If, on the other hand, the atmosphere is perfectly dry, the carbide crumbles and forms a good deal of dust. This is often another source of danger, for the dust readily flies about, and in a lamp it is very apt to stop up the tubes. To prevent all this, M. le Roy pours ordinary petroleum on the broken carbide so as to partly soak the lumps with it. The petroleum retained in the pores of the carbide protects it from damp and prevents the formation both of disagreeable odours and of dust. Carbide so protected can be kept so long as the petroleum has not evaporated in the open air. It is useful to add a very small quantity of nitro-benzine to the petroleum before using it. Carbide protected in this way has also the advantage of giving off acetylene with great regularity when attacked by water.

Calcium Carbide.—The increasing importance of the acetylene gas industry has caused a large amount of attention to be devoted to the manufacture of calcium carbide. Various processes for its production are now before the public, and one of the most recent is the Borcher process, which seeks to make calcium carbide without the use of electrical energy, in a regenerative furnace. The mixture from which it is desired to obtain carbide is fused in a furnace by means of solid fuel and air enriched with oxygen. When the air fed into the furnace contains 60 per cent. of oxygen, a regenerative furnace is not required. With such a furnace, however, 30 per cent. of oxygen will suffice, and the carbon is not oxidized to carbonic acid. The enriched air is heated to about 400° C. before being fed into the furnace, provided that not more than 30 per cent. of oxygen is present. If more than 30 per cent. is present the temperature to which the mixture must be heated is considerably reduced, and iron feed-pipes may be used, otherwise it is necessary to use magnesia pipes. The carbide mixture may be used in the form of compressed cakes, covered with tar and coke.

Alkali Industry and Electrical Processes.—There is usually a budget of useful information in the annual report of the Chief Inspector under the Alkali Acts, and the thirty-fourth annual report recently issued shows that the number of works now registered under the acts in England, Ireland and Wales is 1,052. Of these 86 only are works decomposing salt, and so scheduled as alkali works; while the remainder, 966, carry on processes which are scheduled under the acts of 1881 and 1892. These numbers show a decrease of one alkali and five other works since 1897. There are also 126 works registered in Scotland, bringing the total number of registered works to 1178.

With regard to "alkali works and alkali waste works," the inspector says: "Very few complaints are now received of escape of hydrochloric acid, and the improvement in condensing plant, together with the wider and closer technical knowledge that has characterized the administration of most of the large works grouped under this heading, have naturally made themselves felt in reducing the escapes of this acid and also of chlorine to a low figure. Accidental escapes at times in large scale operations are inevitable, but such have not required the serious attention of the inspectors. In some of the smaller works there is still room for improvement.

Under the head of "Chlorine" the report says: "There is no special development this year for me

to put on record, either in regard to the older processes for obtaining chlorine, or to the newer, electrolytic and otherwise, whose features have been sketched in recent annual reports. The fall in the price of bleaching powder has operated adversely to newer electrical processes that might be awaiting trial on the large manufacturing scale, and has certainly given a check to the development of any process based on nitric acid decomposition. It is in Scotland that the most interesting work has been done this year on this latter description of chlorine process. As stated above, the public has not suffered to any large extent, as in the past, from escape of this gas during 1898, all plant for evolution and absorption of chlorine having been maintained and worked in excellent condition. I regret, however, that the same can not be said of one of the processes incidental to the manufacture of chlorine, involving, as it does, the concentration of sulphuric acid in very large quantities. Much complaint has been received of escape of acid vapour, due principally, if not entirely, to the overpressing of plant and to discharge of the dense vapours into the air at too low a level."

TEXTILE INDUSTRIES.

The fourth edition of the Canadian Textile Directory has just been issued, and is a handsome volume of 563 pages, giving full and most excellently arranged details of the textile trades and traders of the Dominion.

The Board of Trade Returns show the following to be the value of textile machinery exported during June, 1897-98-99.

	1897. £	1898. £	1899. £
To Russia	50,965	127,781	155,328
,, Germany	99,991	86,710	65,636
,, Holland	20,088	22,949	12,084
,, France	62,235	60,136	41,730
,, Other countries in Europe	97,756	101,857	89,131
,, China (including Hong Kong)	12,234	13,810	55,504
,, Japan	48,143	31,499	5,804
,, United States	14,826	15,310	26,979
,, Countries in South America	8,388	6,460	8,808
,, British East Indies	74,260	128,873	91,952
,, Other countries	10,407	24,249	55,640

New Mill in Italy.—A large number of the continental mills have both spinning and weaving machinery, which has been manufactured in England. Italy, a country in which there are no makers of textile machinery of repute, is a particular case in point. The counts spun in Italy are generally found to be low, the mills being equipped with ring frames. A mill which has been recently erected in Busto, Arsizio, Italy, is fitted with electric light and all modern improvements. The total number of ring spindles employed are 26,500, the counts spun being 14's to 24's and from 10's to 30's twist. The machinery was supplied by Messrs. John Hetherington and a French firm of engineers. In addition to the spinning wheel is a large weaving shed which contains 1,500 looms with preparatory machinery, besides bleaching, printing and dyeing plant. The mill altogether gives employment to from 1,500 to 1,600 people.

Recent Improvements in Sizing Machinery.—One of the principal features in connection with the slasher sizing machines is the cone drum system of driving. The usefulness of this system in altering the speed of the machine is generally conceded; but against it is claimed that much annoyance is caused through the slipping and breaking of the driving straps, whilst too much power is absorbed in driving it. Somewhat similar defects are found in the ordinary friction apparatus which drives the beam, and to overcome these and those before referred to, Messrs. Dickenson and Sons, of Blackburn, have been recently applying to their sizing machines improved friction drives, one of which takes the place of the old cone-drum arrangement and its attendant gearing, whilst the other is claimed to be better than the old friction drive which it displaces. The drives are so arranged as to admit of slow, medium, or fast driving, the change from one speed to another being effected from either end, or centre of machine.

Embroidery Effect by Printing.—A German patent has been taken out by B. Thies for a new process for making coloured patterns on fabrics. If a fabric bearing a pattern in relief is passed under a roller supplied with dye, only the raised parts are dyed, if the roller only exerts a slight pressure, and its rotation is independent of the motion of the fabric. As the action of the dye only affects certain parts of the fabric occurring on its surface in the form of a pattern, the fabric looks like embroidery. No new machines are required. By altering the concentration of the printing colour or the ratio below the speed of the roller and that of the cloth, it is possible to vary the effects. A modification of the process is to make the cloth move against the roller; the pattern in relief can be got by weaving, pressing, and mercerising, or the fabric can be laid on a printing cloth in which the reliefs are. If several printing rollers close together are used, very varied effects are produced. The process is said to have already met with much favour.

New Cloth-raising Machine.—Some of the manifest defects in the older style of raising machines were connected with the difficulties of raising a soft weft, to overcome which, the planetary roller machine was introduced. In most of these machines the raising rollers are secured rigidly upon their shafts, and it is here that a new machine, invented by Mr. Chas. Wood, of Heaton Norris, near Manchester, contains an innovation in that the card rollers are not fixed in any way, as far as the means for giving them rotation is concerned. The inventor, who

has spent a lifetime amongst raising machinery, has for many years been trying to lessen the risk of injury to which pieces are subject when being raised, and by the new method any damage to a piece going through the process, however fine and delicate it may be, will be impossible. Apart from this, the machine may also be driven at twice the speed usually employed, and no fibres are torn out and wasted during the process. It is easy to predict for this machine a wide popularity.

MISCELLANEOUS.

Germany's Imports and Exports.—A selection from Germany's January to April report on her imports and exports—in tons:—

	Imports. 1 Jan. to 30 Apr. 1898.	1899.	Exports. 1 Jan. to 30 Apr. 1898.	1899.
Angle and Tee iron	59	156	60,871	65,214
Malleable iron in bars, tyres, plough-shares, &c. ...	6,784	7,653	90,936	73,089
Railway axles, wheels, &c.	986	1,145	10,569	13,362
Bicycles and parts	373	218	600	687
Locomotives	733	810	3,670	2,923
Railway wagons—units ...	45	114	534	2,934
Machinery—chiefly cast iron	15,394	18,560	40,590	48,864

Switzerland as a Machinery Producer.—Switzerland is fast taking an important place as a manufacturer and exporter of machinery. Its exports of machinery during last year amounted to 4,250,000 francs in excess of those for the previous year, while the imports show a gain of 5,250,000 francs for the same period, the imports and exports during each year amounting to about 38,500,000 francs. It is noteworthy that, whereas Switzerland has until recently bought all locomotives used in the country from abroad, during 1898 there were 32 such engines exported from the country, while only 6 were imported. Notwithstanding the great progress which has been made in the native manufacturing industries during recent years, Switzerland in 1898 imported 1271 carriages and wagons, chiefly of German make, and representing a value of 2,500,000 francs.

A New Anglo-Australasian Service.—In August next the White Star Line will inaugurate a regular service of steamers between Liverpool and Australia. The Company have arranged with Messrs. Harland & Wolff, Belfast, to construct five large twin-screw steamers, aggregating about 60,000 tons, for the Australian trade. The first of these, the *Afric*, of 12,000 tons, was launched last November. The *Medic*, of similar dimensions, followed in December, and will shortly be succeeded by the *Persic*, *Runic*, and *Suevic*, making a fleet capable of maintaining a monthly service. The *Medic* will be the first to sail, and the other vessels will follow at regular intervals. These steamers will carry only third-class passengers, and be fitted with extensive refrigerating chambers for the carriage of dairy produce, fruits, and chilled or frozen meats.

Paraguay as a Market for Machinery.—According to one of our Consular reports, Paraguay offers at present a valuable market for agricultural machines and implements. The Consul says: "The farming population with the support of the Government is turning from their previous chief occupation, cattle raising, to agriculture, and especially to grain cultivation. Action is also to be taken for the encouragement of immigration. Manufacturers wishing to take advantage of this favourable opportunity should use other means than correspondence. Experienced commercial travellers with a thorough knowledge of the language and business ability should at once be sent down. It would be well if the travelling salesmen could arrive with their samples of machines and implements before the colonists sent there by the Government, as these colonists at once have to supply themselves with the necessary material."

Machinery Wanted in Peru.—Peru is making an enterprising bid for increased supplies of machinery, and seems to have preferences for that of French manufacture. At all events, the *Moniteur Officiel du Commerce* publishes a request which was made to the French Minister at Lima by a number of Peruvian merchants and manufacturers. They desire to obtain catalogues of the following articles: Steam pumps, hydraulic machinery, boilers, tools, machines and implements for sugar, mining and metallurgic industries, chemical apparatus, as well as all kinds of machinery which are used in weaving, dyeing, tanning, paper manufacturing, etc. These catalogues must contain all the latest price quotations as well as conditions of payment, discount, packing, etc. The French Minister considers this a favourable opportunity for the French manufacturers to create a market for their products in Peru. We imagine it would be worth the while of our own machinery makers to look into the matter.

Australian Demand for Machinery.—A report by the Canadian Commercial Agent at Sydney, New South Wales, indicates that an increasing demand may be expected in agricultural implements and machines, in spite of last year's unsatisfactory harvest, which momentarily limited the demand for binders. Where sun and rain favours the cultivation of wheat, the cattle breeder hires out his land for three or four years with the intention of planting clover at the end of this period, and in this way accomplish a rotation of the crops. Experience has taught how useful it is to plough deeply and sow the wheat in rows with artificial manure, and keep the straw for fodder. From this arises a growing demand for ploughs, ridge ploughs, and ridge drills, which at the same time spreads the artificial manure, binders, and threshing machines. The import of these articles can, however, only take place directly through the manufacturer, as an Australian dealer in machinery hardly cares to go to the trouble and expense of introducing a new article.

Something New in Dairy Machinery.—In the comprehensive display of dairy machinery at the recent "Royal" Show at Maidstone, there

was very much that was interesting to all who are concerned in dairy industry, or in the application of machinery to dairy requirements, but little of importance that was absolutely novel. There was one apparatus, however, which excited a good deal of interest—an improvement in cream separators of the Alpha-Laval type. Up to the present time, in cream separators the inflowing milk has usually passed into the bowl near the centre, and has had to make its way through the wall of cream, which is driven by the centrifugal force near to the centre of the revolving bowl. That has had the effect of retarding the rapidity of separation, and of mixing with the separated milk part of the cream which had already been extracted. The effect of the new invention—American, by the way—which is now fitted to the Alpha-Laval machines, is to introduce the stream of new milk down the whole depth of the bowl, and at that part where the specific gravity of the milk already in the bowl corresponds with that of the new milk; consequently the disturbance caused by the milk coming in is reduced to a minimum, and as a result the rapidity of separation is increased by about one-third, whilst the cost of the machine remains the same, and the power required is not in any way increased.

New Boats for the French Service.—A fresh convention has been made between the French Government and La Compagnie Générale Transatlantique, by which the latter, subject to necessary changes being made at Havre, agrees to put two new boats into service, each having a speed of 22 knots on the trial trip. The first of these boats is to be ready by April 1, 1900, and is to give an average service speed of 17 knots the year round. The second boat is to be ready in July, 1900, and is to give an average speed on its trips throughout the year of 17·5 knots, whilst for the third the speed is to be raised to 18·5 knots. The agreement further provides that if by July 1, 1905, the service speed of these boats should be 10 per cent. less than that of competing vessels of other lines, a new boat is to be laid down and put into service on April 1, 1908, which shall equal the best of the foreign boats. For fifty-two voyages per annum, the company will, up to July 21, 1901, receive a subvention of 5,480,000 francs plus a special premium, not to exceed 1,200,000 francs, and from July 22, 1901, up till July 21, 1911, the subvention will be 5,000,000 francs plus a speed premium which may reach 1,680,000 francs. Hence, setting out from the date named, this company may receive annually from the Government upwards of £260,000 sterling. The company is further given an absolute postal monopoly, and the State further agrees not to subsidise any other competing line. A remarkable feature of the agreement is the disparity between the speeds demanded on trial and the service speeds.

Agricultural Machinery in Argentina.—From a report by the French Consul at Cordoba, in the Argentine Republic, it would seem that that country is becoming an increasingly valuable market for agricultural machinery. This is accounted for in the first place by the rapid development in the cultivation of grain and Luzerne clover, and in the second place, on account of the machines wearing out in a short time, being handled principally by inexperienced people. Thus, the threshing machines in the province of El Entre Rios are said to be in a condition which makes their use dangerous to the people handling them. American manufacturers have already gained a firm foothold in the market. According to a census taken in 1892 there were in use in the province of Cordoba alone 19,909 agricultural machines and implements. To what extent this trade has grown will best be seen from the fact that in 1897 the number had increased to no less than 77,406, an increase of almost 400 per cent. during a period of five years. In 1897 the number of the various machines in use in that province was as follows:—39,474 ploughs, 11,192 harrows, 285 Indian-corn hullers, 320 steam threshing machines, 852 mowers, 686 binders, 1,692 drills, 11,805 agricultural carts, 2,275 wagons of all kinds, and besides, 180 steam threshing machines, which, during the harvest time, are rented out to the small farmers. The French Consul adds that the terms of payment are five months' credit or 5 per cent. discount for cash. The very best way, he considers, for a successful trade in agricultural machinery and implements in the Argentine Republic would be to establish a depot, where the machines can be seen, in Buenos Ayres and Rosario. These two places are the best distributing points.

Hints to Machinery Exporters.—Some valuable hints to manufacturers and exporters of machinery find a place in a report which Mr. George P. Pettit, the United States Consul at Düsseldorf, Germany, sends to his State Department. It deals with the obstacles encountered in sending American machines into Germany, and as similar difficulties are met with in connection with the despatch of British-made machinery to the German markets, some passages in the report may be cited here with advantage. "I have just seen one shipment," says the Consul, "in which three very valuable machine tools were completely ruined, the cast-iron frames being broken in several places. It is impossible to ascertain whether the damage was done by the railways in America, the steamship companies, or by the railways in Germany. Nobody seems to be responsible. It is alleged, however, by those interested that these heavy machines are subjected to very rough handling by the steamship companies. It is said that they jerk them out of the vessels with steam cranes, often hooking to frail castings, which are not strong enough to sustain the weight. Before accepting damaged machines, the German buyer examines them while in the possession of the railway at the final destination, and they are also exhibited to witnesses before being taken from the depôts, resulting in protested

drafts, long and disagreeable disputes, and sometimes expensive lawsuits. Delay in the delivery of the machines has also, in several instances, resulted in heavy losses. In one case, an apparatus valued at over $3,000 was to have been delivered in October, but did not reach Germany until the following February. It had been sold by a German house dealing in American machines, with the agreement that it was to be delivered in November. The result was a suit against the dealer, in which damages for about $2,000 was demanded, and, in turn, the middleman claimed similar damages against the American manufacturer."

On the subject of packing and contracts, the Consul suggests that "To prevent breakage during shipment, all machines and parts of machines should be boxed, when possible, and the cast frames bolted securely to heavy timbers. In some of these machines there can be no doubt that the castings are too light for export without careful packing. Contracts should be made in writing when practicable, and should leave no doubt as to where the responsibility of the exporter ends and that of the German importer begins. . . . Much trouble will also be avoided by detailed specifications, which will prevent disputes as to particular parts of machines, and by the delivery of goods within the specified time. Special care should be taken that the bills of lading show clearly that the machines are in good order, and forwarding agents should be given special instructions to carefully examine them at the seaports for cracks, bends, and breaks, in order that the responsibility for damages may be easily fixed."

Electro-Pneumatic Signalling.—A new departure in the mechanics of railway signalling and interlocking, so far as this country is concerned, has been marked by the installation near the Bethnal Green Station of the Great Eastern Railway of an American system of electro-pneumatic signalling. With that enterprise which is characteristic of the Great Eastern Company, the officials of the railway were not slow either to appreciate the advantages which the system was found by the experience of years of its successful operation in America to present, or to put this appreciation to practical result. The system is the invention of Mr. George Westinghouse, of air-brake and triple-valve celebrity, and the cabin which houses the first installation in this country is favourably placed to afford an adequate test of the efficiency of its working as applied to the conditions of terminal traffic in this country.

The cabin is a very important one, being situated about 300 yards, on the London side, from the Bethnal Green Station, and on the high-level tracks running into the Bishopsgate Goods Depôt, which, before Liverpool Street was built, formed the passenger terminus of the old Eastern Counties Railway. Here traffic of the shunting variety is incessant day and night, and at night, when the rush is at its height, goods caravans pass the box every few minutes. Only a few weeks ago two signal cabins were necessary for controlling the section and its numerous off-shoots; but now all the mechanism has been concentrated in the new edifice devoted to electro-pneumatics.

The absence of the customary imposing rows of levers and the usual accessories of the signal box is marked. The box has two occupants, who place themselves in front of a long rectangular glass-covered case, standing about three feet from the ground, and reminding one of a grand piano with its lid off and the wires laid bare. In front of the apparatus is a rank of small handles, which can be turned from side to side with as much ease as the keys of a piano can be depressed. Turning one of these handles (which are really nothing more than electric switches) applies electricity for the purpose of moving a pneumatic valve, and the valve in turn controls the supply of air to the air-motor which is fixed close by, and performs the actual task of releasing each signal and pulling over each switch to be operated. This dispenses with direct mechanical connection by rod or wire, as well as putting an end to the heavy physical labour involved by pulling over a stiff lever every few seconds. On the rank are 38 handles; of these 12 are painted red and work 25 semaphore arms, and the remaining 26 are coloured black, and manipulate 43 pairs of switches. Each handle is provided with a small button, and the latter must be gently turned before the handle itself can be moved.

In the case of a signal handle the full stroke can be made at once, but on reversing the action, to set the arm back to danger, there are two distinct motions, for the handle automatically stops halfway until the arm has sent a current back to announce that this has been performed. Each signal handle moves in the way a train is coming, and the point handles always stop half-way while being moved over. The silence is marked and is only broken by the telephone, which, with the gramophone arrangement attached, voices the requirements of the shunters in the yard.

Hitherto, by the Board of Trade Regulations, switches have had to be placed within 250 yards of their controlling box, but by the aid of a pipe containing compressed air and a motor, or small cylinder, containing a piston, which is fixed near each switch and attached directly to the switch movement, they can be safely manipulated two or three miles off. Signal posts and switches are equipped with motors, those for working the semaphores being the simpler of the two, but the principle of both may be given as follows: that compressed air admitted to one side or the other of the piston moves the switch or semaphore one way or the other. Immediately adjoining the Bethnal Green electro-pneumatic box is what may be termed the motor-cabin, containing a one horse-power dynamo and two Westinghouse air-pumps (one being kept in reserve), supplying the air pressure, which is brought up from Bishopsgate Low Level, and is a portion of the power generated for working the lifts, hydraulic capstans, etc., at that station and at Liverpool Street. The apparatus in the box proper was manufactured by the Westinghouse Brake Company in America, and was then shipped over and put together by Messrs. McKenzie & Holland, of Worcester.

BRITISH.

IN **The Engineer** for June 30th, Mr. Bryan Donkin, M.Inst.C.E., concludes his papers on "Smoke and its Diminution," and his "Conclusions" are worthy of careful perusal by engineers and manufacturers. On the installation of a new apparatus he insists that a proper eight hours test should be made, working both with and without the apparatus, to prove whether or not the smoke is really decreased:

> All the coal should be weighed and the water evaporated measured. The best practical way of doing this is to plot on paper every minute the actual degree of smoke seen from the chimney, as described in the first article. In this way a zigzag line is obtained, showing all the variations in the smoke emitted during a working day, especially after hand-firing and poking, when the maximum black smoke is always produced. Smoke diagrams of some sort are absolutely necessary to guide the expert or inspector in his observations on the top of any chimney.

Another article deals with the maximum charge system for electric light, and there is a strong leader on the everlasting question of foreign competition. After quoting the opinion of our Consul at Yokohama that "American locomotives are not giving the satisfaction anticipated by the purchasers, and the engines imported from Great Britain still hold the record for durability and freedom from breakdown," the article says:

> It will be a very interesting outcome of American competition if the experience of the Midland, Great Northern, and other companies which have bought locomotives from America should prove, after a fair trial, to be similar to that of the Japanese. Moreover, the Japanese are not the only foreign people who have been induced to purchase American locomotives, and have had reason to repent of doing so. It is quite possible that in some departments of iron and steel production our transatlantic rivals may be able to undersell us quite squarely—without any recourse to the question of surplus, but simply by virtue of cheaper production of articles identical, or as nearly as may be identical, in quality.

The issue for July 7th has a leader which takes the form of a reply to a criticism by an English engineer in Japan on the comparative merits of English and American locomotives, in which some severe strictures are passed on some English-built locomotives. The same issue contains the first of a series of illustrated articles by the *Engineer's* special commissioner on "Automatic Couplers on American Freight-Cars"; a descriptive account of the new American battleship *Maine*, of which a double plate is given as a supplement; an illustrated description of a six-wheeled coupled goods engine for the Furness Railway; a report of the proceedings at the summer session of the Borough and County Engineers at Cardiff; an elaborate description of the works of the Diamond Match Co., at Seaforth; an illustrated article on the launch of the new German battleship *Kaiser Wilhelm der Grosse;* and various other important contributions make up a very strong number.

The principal features of **Engineering** for June 30th are the concluding portion of their special article on the Atbara River bridge, with numerous detail drawings; further instalments of Captain Longridge's articles on "Dredging for Gold," and Messrs. Parshall and Hobart's on "Electric Generators"; illustrated articles on the Japanese torpedo-boat destroyer, *Akebono*, and on the Civil Engineering and Transport building at the Paris Exhibition; and the concluding portion of Mr. Harry G. V. Oldham's paper on "Evaporative Condensers." The annual reports of the engineers to the great Boiler and Engine Insurance Corporations form the basis for a leading article on the "Strength of Boilers." The principal article in the issue for July 7th deals with the famous "Vulcan" Works at Bredow, near Stettin, which affords opportunities for a number of very interesting illustrated comparisons of representative German and British steamers, and of Atlantic liners and their performances. There are further instalments of the descriptive articles on the Westinghouse Electric Works at Pittsburg, and the works of Messrs. Schneider & Co., at Creusot. The subject of American locomotives for the Midland Railway is also dealt with, and a supplement gives detail drawings of an American goods engine for that system. The leading articles deal with the amendment of the Companies Act, Australian Copper, and the Telephonic Communication Bill.

The **Colliery Guardian** of June 30th gives prominence to an article on "The Root Principles of Mine Ventilation," and in its issue of July 7th Mr. George Johnson, F.S.S., A.I.S., deals exhaustively with the subject of coal waggon estimates and costs. An exhaustive illustrated article on "Progress in the Electric Firing of Mine Shots" will be read with interest by many. The serial articles on the "Yorkshire Coalfield" still form a regular feature of the *Colliery Guardian*.

The **Mechanical World**, in the issue for July 7th, contains instalments of its serial articles on "Modern Engineering Workshop Practice;" "Marine Engine Design;" and "Locomotive Design;" which are excellent examples of what such matter should be. A new serial starts in that number on "Corliss Valves and Gears." The issue for July 14th contains, besides other contributed

matter, an instalment of the serial article on the "Electrical Transmission of Power in Mining," by Mr. W. B. Esson, and also of that on "Shipbuilding in Theory and Practice."

In the **Electrician,** the number for June 30 has an interesting note on the present state of electrical engineering education in Japan. The two notes on Wehnell's interruptor in "Contemporary Electrical Science" are of interest. As a purely non-electrical point, we may perhaps object to the word "disassociation." It is hard to say where "dissociation" hasn't the advantage over it. Illustrated articles are given on the Taunton Electrical Supply Works, an electrical tool for removing wool from skins after they have themselves been removed, and on the Municipalisation of the Telephone (a paper read before the Municipal Electrical Association).

In the **Electrical Review** for July 7th there is a leading article, "A Sub-Department of State," on the relations between the Government and the combined Eastern and Eastern Extension Telegraph Companies. The report of the Pacific Cable Committee is continued, and there are articles on electric tramway schemes for London and the Volta Centenary Exhibition at Como. There are, of course, the usual parliamentary and legal and city and market reports, and notes on electric lighting progress in the towns. There is also a special illustrated article on the Hull Electric Tramways. The principal remaining contents of the journal are articles on electrolytic zinc production, foreign electric machinery, and on electrical power transmission.

AMERICAN.

The July number of the **American Engineer** (New York), after reports of the Thirty-third Annual Convention of the Master Car Builders' Association and of the Thirty-second of the American Railway Master Mechanics' Association has the usual stock subjects of the day, such as automatic coupling and American locomotives for British railways. There is also a review of Dr. Thunston's article on smoke suppression in *Science.* Among Dr. Thunston's conclusions, the most important is that the chimney top should be visible to the man at the furnace.

Engineering News (New York), in the number of June 8, has an interesting illustrated article on the 1,500 h.p. four stage air compressor built for the American Air Power Company of New York. The machine will compress per minute, at average rate of running, about 20 cubic feet of air to a pressure of 2,500 lbs. per square inch. There are other important articles on the Manhattan Valley Viaduct (illustrated), and on the colour of railway night signals. The American railway authorities are finding out the advisability, as we on this side did some time ago, of rejecting white signal-lights on account of the danger of confounding them with private lights. The following number of the journal publishes an interesting illustrated account of the fall of a trestle bridge under a train at Wisconsin. There are also articles on through transportation on common roads and street railways and on the new railway from Canton to Hankow.

The June number of **Power** contains an illustrated account of the electric lighting plant at the Waldorf Astoria Hotel, New York, a report of the Washington meeting of the American Society of Mechanical Engineers, and several other items of interest and importance.

CONTINENTAL.

Stahl und Eisen for June 15th contains an article on the more important changes in Prussian land-law, an illustrated notice of the "Deutscher Kaiser" Ironworks at Bruckhausen, and articles on blast-heating at the Estra Steel Works; on manganese in the acid Martin process; testing hard cast-iron wheels; on the Swedish-Norwegian Union Railway, Lulea—Ofoten; on the new buildings of the Machinery and Iron-smelting School at Duisburg; and on the question of labour agencies.

Le Génie Civil for June contains an illustrated article on the new railway station at Tours, with its double semicircular arch like that of the Great Northern Railway at King's Cross. A "Didactic Study of the conditions of Establishing Mechanically Propelled Vehicles on Roads" reaches its tenth instalment (on brakes). There is also an account of the second exhibition of motor-cabs in Paris, and short articles on the effect of chilling on the mechanical properties of steel, and on an extensible centering for sewer construction. The number for July has an illustrated article on the Palace of Mines and Metallurgy at the Paris Exhibition of 1900, and the continuation of the "Didactic Study of the conditions of Establishing Mechanically-Propelled Vehicles on Roads." Other chief articles concern the lighting of tramcars with acetylene.

L'Industrie for July 2nd contains an illustrated article on milling machines; on the utilisation of tide and wave-power; on the Meldrum-hearth; and a concluding article on the application of mechanical motive-power to tramway traction. The number for July 9th contains articles on the electric propulsion of torpedoes; on electric heating; the famous Nernot lamp, about which so much ink is being spilt at present; the causes of death from continuous currents of electricity, and the value of water power. Among the miscellaneous matter is an interesting article on the industrial future of the extreme East.

The **Revue Industrielle** of July 8 has an illustrated article on the Cabrier system of separating unburnt coke or coal from furnace ashes. The instalment in this number of the series of articles on automotors is concerned with lubrication, and several good English and other lubricators are described and figured. Foureau's elastic friction speed multiplier is the subject of an illustrated notice. In the section on mineral chemistry notice is taken of the success met with by Moissan in replacing platinum by copper in the apparatus for the electrical preparation of fluorine.

REVIEWS OF BOOKS AND CATALOGUES...

RECENT BOOKS.

Les Progrès Récents dans la Teinture et l'Impression des Tissus, par Antonio Sansone. Paris: G. Carré and C. Naud, 1899.

The French edition of Sansone's work is naturally more up to date than its English predecessor. The first chapter of the French work deals with machines, and recent discoveries and innovations in dyeing and printing processes. This is the best part of a good volume, but we think more might have been said about Brandt's process for discharge printing of white and red on indigo ground. This, as Mr. Sansome himself observes, is one of the most important improvements made of late years in connection with pattern dyeing with indigo. The next chapter is on fastness. Here the remarks on the testing of oxidation aniline-black are particularly well chosen. The resistance of aniline-black is remarkable, and a marking ink, known as Melanyl, the action of which depends upon its formation, is actually, when properly used, more durable and resistant to chemical action in general than any fabric on which it can be used. The information is not only full, but extremely accurate, and if the further instalments of the work are as good and up to date as the present one, which there is of course every reason for anticipating, the book will form an extremely valuable vade-mecum for professors of the vast industry with which it is concerned.

Lockwood's Dictionary of Terms used in the Practice of Mechanical Engineering. London: Crosby Lockwood and Son, 7, Stationers' Hall Court, Ludgate Hill, E.C.

The author of this work is informatory; he knows what he is writing about; and he is modest. Our "Foreman pattern maker" does not even give his name, but he comes to his task equipped with twenty-seven years' practical knowledge of factory life. "The drawing office, pattern shop, foundry, fitting, turning, smiths' and boiler shops," are, he says in his preface, "familar to me in my capacity as foreman; therefore, I have drawn in this work on the experiences of my daily life, coupled with some necessary amount of self-culture." This is quite satisfactory, and we do not hesitate to say that the result not only does our "Foreman pattern maker" infinite credit, but would give points to many who tackle similar work with greater pretensions and more slender practical resources.

Here and there, too, a definition or two do not quite please us. Let us take that given for "Friction," for example. It reads thus: "The resistance to motion which is set up when two rough surfaces are moved one over the other. The amount of friction is independent both of the rate of motion of a body and of the extent of surfaces in contact." Now this is excellent so far as it goes, but it does not cover the ground. Friction, for one thing, does not only exist where rough surfaces are in contact, but where smooth are as well. Friction is certainly a most difficult entity to define in its relation to mechanism, but still the description given is surely crude and inadequate. Much more for example may be said about the antithesis of friction, namely, lubrication, which is defined in these terms in the work before us: "The distribution of an unguent over bearing surfaces to preserve them from the heating which results from the surfaces in actual contact." This is a better definition, and in fact almost proves the inadequacy of the former one, inasmuch as the term "bearing surfaces" does not suggest "rough surfaces," but quite the reverse, and yet, of course, the use of lubricants is necessary.

We make these references in no spirit of fault-finding or hypercriticism, for we regard the work as a whole as a really valuable one for the practical mechanic.

NEW CATALOGUES.

We have received the current issue of the catalogue of Messrs. FLEMING, BIRKBY, AND GOODALL, LD. This well-known firm has several factories in Yorkshire, the chief one being at Halifax, and its wares have and deserve an extensive sale. Their specialities are oak-tanned leather belting of the very best quality, and other leather goods, such as hydraulic leathers, cotton belting, india-rubber goods, Fleming's "Teon" belting, and "Gilbert" wooden split pulleys, besides cards for cotton and other mill furniture. The catalogue is excellently printed and illustrated.

We are also in receipt of the illustrated description of **Green's Economiser** for feed water heating. The immense and increasing use of this apparatus is a convincing testimony to its efficacy and to the saving of fuel. The book under notice contains the most complete and detailed description of the apparatus and instructions for use and for meeting every possible emergency. There are numbers of most excellent diagrams and illustrations, and the whole get up of the book is most satisfactory. We understand that Messrs. Green have published the catalogue under review in several languages. The office address is E. Green and Son, Ld., Exchange Street, Manchester, and the works are at Wakefield.

The latest list (No. 5) of Broadbent's Centrifugals, made by THOS. BROADBENT AND SONS, LD., Huddersfield, has reached us. It might seem superfluous to recapitulate these widely-known machines, which are used wherever they are known, but these remarks may possibly be read by users of hydro-extractors to whom the name of Broadbent presents no associations with this type of machine. They require no foundation or friction gear, and as they are not belt-driven, and are impervious to wet, they will work in the dampest situations. They are driven direct, each by its own small steam engine, and run at very high speed, but are nevertheless extremely durable.